

CHAPTER 2

Neck Musculoskeletal Disorders: Evidence for Work-Relatedness

SUMMARY

Over 40 epidemiologic studies have examined physical workplace factors and their relationship to neck and neck/shoulder musculoskeletal disorders (MSDs). Among these studies are those which fulfill rigorous epidemiologic criteria and appropriately address important issues so that causal inferences can be made. The majority of studies involved working groups with a combination of interacting work factors, but certain studies assessed specific work factors. Each of the studies we examined (those with negative, positive, or equivocal findings) contributed to the overall pool of data for us to use in assessing the strength of the work-relatedness using causal inference.

There is **evidence** for a causal relationship between highly repetitive work and neck and neck/shoulder MSDs. Most of the epidemiologic studies reviewed defined "repetitive work" for the neck as work activities which involve continuous arm or hand movements which affect the neck/shoulder musculature and generate loads on the neck/shoulder area; fewer studies examined relationships based on actual repetitive neck movements. The two studies which measured repetitive neck movements by measuring head position (using frequency and duration of movements), fulfilled the most stringent epidemiologic criteria, showing strong associations with neck/shoulder MSDs. In those studies defining repetitive work involving continuous arm or hand movements affecting the neck/shoulder, nine studies were statistically significant and had odds ratios (ORs) greater than 3.0.; eight studies fulfilled all the epidemiologic criteria except the exposure criteria, and measured repetition for the hand/wrist and not for the neck. Of these, 3 were statistically significant and had ORs greater than 3, five had nonsignificant ORs, all under 2.0.

There is also **evidence** for forceful exertion and the occurrence of neck MSDs in the epidemiologic literature. Most of the epidemiologic studies reviewed defined "forceful work" for the neck/shoulder as work activities which involve forceful arm or hand movements, which generate loads to the neck/shoulder area; no study examined a relationship based on actual forceful neck movements. Of the 17 studies addressing force as one of the exposure factors, five studies found statistically significant associations, but did not derive ORs; two studies found ORs greater than 3.0, seven studies from 1 to 3.0, and 2 studies with ORs less than 1.0. Many of the studies relating measured force (as workload, etc.) to MSDs are in the biomechanical and ergonomic literature.

There is **strong evidence** that working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck-shoulder muscles are at increased risk for neck-shoulder MSDs. Consistently high ORs were found (twelve statistically significant studies with ORs over 3.0) providing evidence linking tension-neck syndrome with static postures or static loads.

The epidemiologic data were **insufficient** to provide support for the relationship of vibration to neck disorders. At this time, further studies must be done before a decision regarding causal inference is made. The few prospective studies which have included interventions to decrease workplace exposures that include decreasing repetitive work and less extreme working postures showed a decrease in the incidence of neck MSDs, and an improvement in symptoms among affected workers. The data on intervention provide additional evidence that these disorders are related to workplace risk factors.

INTRODUCTION

Studies from the United States have generally classified neck disorders separately from shoulder disorders when evaluating work-related risk factors. Scandinavian studies examining work-related factors, on the other hand, have often combined neck and shoulder MSDs into one health outcome variable. This was based on the concept that several muscles act on both the shoulder girdle and the upper spine together. We have divided our reviews of the neck and shoulder MSDs into 2 chapters: Chapter 2 addresses neck and neck-shoulder MSDs and Chapter 3 addresses shoulder MSDs.

Our discussion of the evidence for work-relatedness of the neck will include criteria Tables 2-1 through 2-6 and Figures 2-1 through 2-6. Shoulder MSDs will be discussed in the next chapter.

Epidemiologic studies have defined neck MSDs in one of two ways: (a) by symptoms occurring in the neck (usually with regard to a specific duration, frequency, or intensity), or (b) by using both symptoms and physical examination findings.

The prevalence of reported MSDs is generally lower when they are defined using both symptoms and physical examination results than when defined using symptoms alone. For example, the prevalence rate of tension neck syndrome (TNS) among male industrial workers in the United States was reported to be 4.9% from interview data and 1.4% when case definitions included physical exam findings [Hagberg and Wegman 1987]. The percent of work-related MSD cases defined by physical examination findings to those defined solely by

symptoms has ranged from approximately 50% (Silverstein et al. [1987]; Blåder et al. [1991]; Bernard et al. [1993]; Hales et al. 1994]) to about 85% (Andersen and Gaardboe (1993)). Forty-seven of the listed studies referenced included physical examination findings in their health outcome assessment criteria.

Many of the neck and neck/shoulder MSD studies referenced in the tables were part of larger studies that inquired about musculoskeletal symptoms and physical findings in multiple body sites. In most of these studies, there were no separate ergonomic exposure observations or measurements made that pertained to the neck region (e.g., there were no neck posture observations, neck angle measurements, neck work-load assessment, trapezius electromyographic testing, etc.). In these studies, the primary interest and measurement strategies focused on the hand and wrist region (e.g., Kuorinka et al. [1979]; Silverstein et al. [1985]; Ohlsson et al. [1989]; Hales et al. [1989]; Kiken et al. [1990]; Baron et al. [1991]). In the studies, workers were categorized only by hand/wrist exposures. Hand/wrist categorization will not reflect exposures of the neck region (or other musculoskeletal sites). For example, workers who may have frequent and rapid awkward postures of the neck, but less frequent or extreme postures of the hand and wrist region may be misclassified as low risk if classification depends only on hand/wrist exposure. In general, we have given these studies less weight because of a significant potential for misclassification.

The text of this section on neck and neck/shoulder MSDs is organized by work-

related exposure factor. The discussion within each factor is organized according to the criteria for evaluating evidence for work-relatedness in epidemiologic studies using the strength of association, the consistency of association, temporal relationships, exposure-response relationship, and coherence of evidence. Conclusions are presented with respect to neck and neck/shoulder MSDs as a single disorder for each exposure factor. Summary information relevant to the criteria used to evaluate study quality is presented in Tables 2-1 through 2-6. A more extensive summary, which includes information on health outcome, covariates, and exposure measures is presented at the end of this chapter.

Studies Included in Neck MSDs Tables

Forty-six epidemiologic studies dealing with neck MSDs and 23 dealing with neck-shoulder MSDs appear in the summary tables. Of the studies, 38 were cross-sectional, 2 were case-control studies, and 6 were prospective studies. Among all the studies pertaining to the neck or neck/shoulder area, 35 had participation rates of over 70%, 3 had less than 70%, and 8 did not report their participation rates.

REPETITION

Definition of Repetition for Neck and Neck-Shoulder MSDs

For our review of the neck or neck/shoulder region, we chose those epidemiologic studies that examined repetition or repetitive work activities and MSDs. Studies generally address repetition as cyclical work activities that involved either: (1) repetitive neck movements (e.g., the frequency of different head positions during a cycle), or (2)

repeated arm or shoulder motions that generate loads to the neck/shoulder area (e.g., trapezius muscle). Most of the studies that examined repetition or repetitive work as a potential risk factor for neck or neck/shoulder MSDs had several concurrent or interacting physical work-place factors that were being evaluated. Therefore, repetitive work was not necessarily considered the primary exposure factor, but was considered along with the other work factors.

Studies Reporting on the Association of Repetition as a Work Factor for Neck and Neck/Shoulder MSDs

Either the risk factor “repetition” or “repetitive work” was included in 26 studies as a factor for selection of the study population in their examination of neck and neck/shoulder MSDs in the workplace. However, only a handful of these studies examined repetitive movements of the neck. Few of these studies observed or measured: (a) the frequency or duration of tasks pertaining to the neck, (b) the ratio of work-time-to-recovery time for neck or neck/shoulder involvement, or (c) the percentage of the workday spent on repetitive activities involving the neck. Instead, studies tended to compare and contrast the prevalences of neck symptoms and/or physical findings in workers in occupations requiring a combination of forceful, repetitive movements and extreme postures of the upper extremities (mainly of the hand/wrist) to workers in occupations without those requirements.

Twenty studies that mentioned repetitive work or repetitive movements found a

statistically significant positive association between repetition and neck or neck/shoulder MSDs; 6 others had non-significant findings (Tables 2-1 and 2-2, Figures 2-1 and 2-2). In terms of magnitude of the association, 11 studies had odds ratios greater than 3.0, 11 had ORs between 1.0 and 3.0, and none had an OR less than 1.0. Four studies did not report their results in terms of ORs or Prevalence Rate Ratio (PRRs), although all of these found significant associations ($P<0.05$).

Studies Meeting the Four Evaluation Criteria

Of the 27 investigations (see Tables 2-1 and 2-2), 2 fulfilled all four evaluation criteria outlined in Ohlsson et al. [1995]; and a series of papers from a cohort investigation by Kilbom et al. [1986]; Kilbom et al. [1987]; Jonsson et al. [1988]. Only the Ohlsson study reported ORs. The investigations assessed repetitive work as an independent variable in terms of frequency and duration of neck movements.

In the cross-sectional study by Ohlsson et al. [1995], female industrial assembly-line workers exposed to repetitive tasks with short (< 30 seconds) cycles were compared to 2 referent groups: 68 former assembly workers and 64 other workers with no repetitive exposure at their current jobs. Industrial workers had to perform tasks with a posture requiring an intermittently flexed neck and elevated arms, which were abducted intermittently. Workers and referents had neck/shoulder symptom(s) and physical exams performed by a single examiner. The examiner was blinded to exposure status but not completely to group status. Ergonomic exposure assessment was extensive. It included videotaping, observation, and analysis of postures,

including measurements of critical angles (15° and 30°) of flexion of the neck. Two independent readers determined frequency, duration, and critical angles of movement for each variable by taking the average of the two readings. Weekly working time, work rotation, patterns of breaks, individual performance rate (piece rate) were recorded and used in the analysis. The study controlled for age, gender (only females were included), and psychosocial variables ("tendency for stress" and "worry").

The other study that fulfilled the four criteria concerned a 3-year prospective study written up in a series of articles Kilbom et al. [1986]; Kilbom et al. [1987]; Jonsson et al. 1988]. Female electronic workers in highly repetitive tasks with static postural loads to the neck and shoulder areas were followed over a 3-year period. In the second year, some of the employees had workplace interventions that decreased the number of repetitive tasks involving extreme neck and shoulder postures, while others continued to work at unaltered tasks. Three separate physical exams were carried out at yearly intervals, the first one initially assessing tenderness on palpation, and pain, or restriction with active and passive movements. Ergonomic assessments occurred at the outset of the study and included video analysis of postures and movements of the head, shoulder, and upper arm. The evaluation recorded work-cycle time and number of cycles per hour; time at rest for the arm, shoulder, and head; total number of rest periods; and average and total duration per work cycle and hour. (The method was designed to study short-cycle repetitive work under visual control.) The mean number of neck forward flexions $> 20^\circ$ per hour was 728 (standard deviation

[s.d.] 365) in the initial 96 workers. The participation rate of the study was 72% after 3 years; the investigators analyzed several variables separately for dropouts and found no significant differences with regards to medical status, physiologic capacity, working technique, or work history. The investigators performed step-wise logistic regression with deterioration of disorders or remaining healthy in the different locations (neck and neck/shoulder) as the two dependent variables. Age, muscle strength, job satisfaction, and high productivity were included in the logistic regression analyses of these studies. Video analysis and observation were used to assess repetitive exposure on all subjects, using work cycle time, number of cycles per hour, as well as number of neck flexions per hour as criteria. Work cycle time varied between 4.6 and 9.1 min, with a mean value of 6.6 min.

Strength of Association for Repetition

In the Ohlsson et al. [1995] study, the OR for the association between repetitive work related to the neck and any neck/shoulder diagnoses was 4.6; for a diagnosis of tension neck syndrome, it was 3.6.

For the cohort study carried out by Kilbom et al. [1986], at the 2-year follow-up, the number of neck flexions per hour appeared as a strong predictor for deterioration to severe disorders of the neck. Improvement to a “healthy status” classification from Year I to Year II was seen with reallocating workers to more varied work tasks (which required a reorganization of monotonous and repetitive work tasks). The new tasks were characterized as more dynamic and varied and included only occasional sitting tasks, caretaking work, surveillance of

machinery, or assembling of bigger and heavier equipment. The article documenting the last phase of the cohort study by Jonsson et al. [1988] did not specifically address the neck but broadened the health outcome definition to include the neck/shoulder area and the rest of the upper extremity, using “cervicobrachial region” as the health outcome of interest. A significant association between deterioration of health status of the cervicobrachial region between Year II and Year III of the study and “work cycle, total time” at the $p < 0.05$ level was found (ORs were not given).

Studies Meeting at Least One of the Four Criteria—Strength of Association

Of the studies that found significant ORs over 3.0 but did not mention or fulfill all of the criteria, almost all focused on working groups with a combination of repetitive and forceful work and compared them to either population referents or groups in occupations with lower exposure. Almost all were cross-sectional surveys. These studies used health outcomes from symptom surveys and self-reported workplace exposure (no direct observations) and either compared symptomatic workers (neck MSD cases) to asymptomatic workers in the same workforce (e.g., Yu et al. [1996]; Bergquist et al. [1995]; Schibye et al. [1995]; Hunting et al. [1981]) or in other occupations (e.g., Liss et al. [1995]; Anderson et al. [1993]; Milerad et al. [1990]; Onishi et al. [1976]). Onishi et al. [1976] found significant differences in neck/shoulder MSDs ($OR=3.8$) between groups involved in repetitive upper limb operations and office workers. They found workers involved in repetitive activity had 10% to 30% MVC of the trapezius muscle. They concluded that habitual neck or shoulder muscle fatigue is

caused by repetitive tasks that result in localized tenderness and may be a precursor to chronic MSDs.

Andersen and Gaardboe [1993a] used a cross-sectional design to compare sewing machine operators with a random sample of women from the general population of the same region. A neck case required a strict pre-determined symptom and physical examination definition. Exposure was assessed through observation and categorization of jobs, based on the authors experience and judgements. However, the main interest for exposure assessment was duration of exposure as a sewing machine operator. Statistical modeling controlled for age, having children, not doing leisure exercise, smoking, socioeconomic status found a significant trend for "neck/shoulder syndrome" in relation to years of exposure as a sewing machine operator, with ORs from 3.2 to 36.74. The OR for the lowest exposure category, 0-7 years, was not statistically significant, although the higher exposure levels were. For this study, the exposure classification scheme does not allow separation of the effects of repetition from those of force, and there was no precise measure of repetitiveness.

Baron et al. [1991] studied neck MSDs in 124 grocery store checkers and 157 other grocery store workers who were not checkers. The neck MSD case definition met pre-determined symptom physical exam criteria. Physical examinations had higher participation rates among the checkers (85%) than among the referents (55%). Telephone interviews to non-checkers resulted in questionnaire completion by 85% of the non-checkers. The OR for neck disorders among checkers was 2.0 (95% confidence interval [CI] 0.6-6.7), in a model

that included age, hobbies, second jobs, systemic disease, and obesity.

Bergquist et al. [1995] carried out another study comparing office workers using video display terminals to those who did not. A physiotherapist's diagnosis of tension-neck syndrome was used to define a case. Exposure assessment was based on both self-reports and the investigators' observation of work postures, movements, and measurements of heights of work-station equipment in conjunction with the user. Statistical modeling included several individual factors, organizational factors and ergonomic factors. For "tension neck" syndrome, no factor related to repetitive work was found to be significantly related.

Blåder et al. [1991] surveyed 199 sewing machine operators from 4 plants. Of the 155 who reported shoulder or neck pain, 131 were examined. Exposure assessment was by questionnaire and addressed employment duration and hours per week. Authors stated that the study involved a control group, and took into account psychosocial factors but the results were not included in the article. Both employment duration and working more than 30 hours per week were found to be statistically significant at the $p < 0.05$ levels. For this study, the exposure as duration of work (per week and per years) does not allow separation of the effects of repetition from those of force. There was no direct measure of repetitiveness.

Ekberg et al. [1994] carried out a case-control study involving cases from a semi-rural community in southern Sweden who had consulted a community physician for MSDs of the neck, shoulder, arm, or upper thorax. Cases had to have been ill immediately prior to physician visit and

have been on sick leave less than 4 weeks. Cases were excluded for trauma, infectious causes, accident, malignancy, rheumatic disease, abuse, or pregnancy. Controls were randomly selected from Swedish insurance registry. Exposure was obtained by questionnaire. The analysis showed that for neck disorders with precise repetitive movements the OR was 3.8 for medium exposure and 15.6 for high exposure comparing jobs with low force and low repetition. Gender, immigrant status, work pace, and current smoking were also analyzed in the logistic model.

Ekberg et al. [1995] surveyed 637 Swedish residents for the presence of neck symptoms in the past six months. Exposure was based on questionnaire responses. 20 questionnaire items on physical work conditions which were factor analyzed. Age, smoking, exercise habits, and family situation with preschool children were not significantly associated with symptoms. Repetitive movements demanding precision was found to be have an OR= 1.2 for neck pain.

Hales and Fine [1989] compared 89 female workers in 7 high exposure jobs to 25 female poultry workers in low exposure jobs employed in poultry processing. Neck case definition required symptoms and physical examination findings that met pre-determined criteria. Exposure assessment was based on hand wrist assessment of forceful and repetitive jobs. No assessment of neck repetition was performed. Twelve percent of workers in high risk jobs versus 0 were found to have neck MSDS.

In a study of VDT users in a range of jobs (data entry to “conversational” VDT use), Hunting et al. [1991] used a case definition requiring symptoms and physical exams,

and an extensive exposure assessment using questionnaire, observation and measurements of work-stations, and body posture measurements using a prescribed method. Data entry terminal users, whose tasks required more extensive repetitive work than traditional office workers, found an OR of 9.9 with the comparison. There were no adjustments for confounders in this analysis.

Kamwendo [1991] compared 420 medical secretaries with frequent, significant neck pain to those with few episodes based on questionnaire responses. Exposure was also questionnaire based. The analysis was controlled for age and length of employment. A surrogate for repetitive work consisted of hours sitting or working with office machines with high exposure equal to 5 hrs or more/day.

Kiken et al. [1990] also studied poultry workers at two plants with exposure to highly forceful, highly repetitive jobs and compared them to other poultry workers with less exposure. Neck case definition required symptoms and physical examination findings that met pre-determined criteria. Exposure assessment was based on hand wrist assessment of forceful and repetitive jobs. No assessment of neck repetition was performed. Job turnover was around 50% at plant 1 and 70% at plant 2; making survivor bias a strong possibility.

Kuorinka and Koskinen [1979] studied occupational rheumatic diseases and upper limb strain among 93 scissor makers and compared them to the same group of department store assistants (n=143) that Luopajarvi et al. [1979] used as a comparison group. Temporary workers and

those with recent trauma were excluded from the scissor makers group. Exposure assessment included videotape analysis of scissor maker tasks, however exposure assessed for the hand and wrist region and not the neck. No formal exposure assessment was conducted on the shop assistants. Health assessment involved interview and physical examination by a physiotherapist following a standard protocol. Diagnoses of tension neck syndrome were determined using predetermined criteria [Waris et al. 1979]. In problem cases, orthopedic and psychiatric teams determined case status. It is unclear whether cashiers were excluded from the comparison group in this study, as they were in the Luopajarvi et al. [1979] study. The study group was 99% female.

Luopajarvi et al. [1979] compared the prevalence of neck/shoulder disorders among 152 female assembly line packers in a food production factory to 133 female shop assistants in a department store. Exposure to repetitive work, awkward hand/arm postures, and static work was assessed by observation and videotape analysis of factory workers. No formal exposure assessment was conducted on the department store workers; their job tasks were described as variable. Cashiers were excluded, presumably because their work was repetitive. No formal assessment occurred for neck/shoulder repetition. The health assessment consisted of interviews and physical examinations conducted by a physiotherapist; and diagnoses of tension neck syndrome were later determined by medical specialists using these findings and predetermined criteria (95% CI 2.63-6.49). Age, hobbies, and housework were considered in the analysis.

Milerad and Ekenwall [1990] compared the self-reported neck and neck/shoulder symptoms between dentists and pharmacists. Dentists had been considered the high risk group because of awkward postures and repetitive use of small hand tools. Exposure was based on self-reports. The authors examined several covariates and stratified by gender for their analysis. No difference between groups in leisure time, smoking, systemic disease, and exposure to vibration.

Ohlsson et al. [1989] studied 148 electrical equipment and automobile assemblers, 76 former female assembly workers who quit within 4 years and compared these two groups to 60 randomly sampled females from general population. A case was determined by questionnaire; exposure was based on job categorization and questionnaire responses. Repetitive exposure was based upon number of items completed per hour. The work pace divided into four classes: (1) Slow: <100 items/hr; (2) Medium: 100 to 199 items/hr; (3) Fast: 200 to 700 items/hr; (4) Very Fast: >700 items/hour. The OR increased with increasing work pace, except at very high paces, where there was a decrease. This was attributed to "selective quitting of subjects with complaints, only the healthiest being left in the assembly work."

Onishi et al. [1976] compared several groups of workers with varying exposure to repetitive tasks. Health outcome was based on symptoms of shoulder stiffness, dullness, pain, numbness; pressure measured by strain transducer at which a subject felt pain; and a physical exam. Observation and measurements of some job tasks, including some measures of repetition then job categorization was done. Based on job

categorization and job analysis, taking into account shift length, activities, number of breaks, repetitive movements of the hands, arm manipulations, length of employment, observation, there wasn't a difference between workers with tenderness threshold above 1.5 kg/cm² and those below with respect to age, height, weight, skin fold thickness, grip strength, upper arm abduction strength, and back muscle strength.

Punnett et al. [1985] compared neck/shoulder MSDs based on symptom reporting alone in 162 women garment workers and 76 women hospital workers such as nurses, laboratory technicians, and laundry workers. There was a low participation rate among the hospital workers. Eighty six percent of the garment workers were sewing machine operators and finishers (sewing and trimming by hand). The sewing machine operators were described as using highly repetitive, low force wrist and finger motions, while the finishers had shoulder and elbow motions as well. The exposed garment workers likely had more repetitive jobs than most of the hospital workers. The neck/shoulder cases were found to lift both the "typical" and "heaviest" loads with greater frequency than non-cases.

Sakakibara et al. [1995] found among orchard workers that neck shoulder MSDs based on symptom and physical findings were significantly higher when performing pear bagging than when apple bagging. Exposure was based on measurements of specific angles of the neck and shoulder and job tasks in a representative worker. ORs were not derived in this study. Confounders were not checked for in this study.

Sakakibara et al. [1987] did not include physical exam findings in the case definition of neck and neck/shoulder MSDs when comparing workers bagging pears versus apples. Exposure was again based on measurements of job tasks by a representative worker.

Schibye et al. [1995] followed up 303 sewing machine operators at nine factories representing different technology levels who completed a questionnaire in 1985. In April 1991, 241 of 279 traced workers responded the same 1985 questionnaire. Operators still working were compared to those who moved to other employment in 1991. Exposure was assessed through a questionnaire asking type of machine operated, work organization factors, workplace design factors, units produced per day, the payment system, and the duration of employment as a sewing machine operator. Although the authors state that the analysis did not show that neck symptoms among workers who had worked as a sewing machine operator to be significantly related to exposure, exposure time, or age, there was a significant drop-out rate of those above 35 years.

Rossignol et al. [1987] chose 38 random sites from Massachusetts workers with more than 50 employees, and selected 191 workers from computer and data processing services, and public utilities and the Commonwealth Government. Subjects were selected after the observation of the worksite. A self-administered questionnaire case definition was used for neck MSD. Exposure was also based upon self reports of number of hours worked each day with a keyboard machine with a VDT. Analysis controlled for the

following confounding: age, cigarette smoking, industry, and educational VDT training.

Yu et al. [1996] chose to compare 90 data entry, data processing, and computer programmers from an International Bank in Hong Kong and 61 infrequent users of VDTs. Both neck MSD case definition and exposure assessment was based on symptom data. Analysis controlled for “age and gender, and other covariates” (as stated in the paper). For frequent VDT use an OR of 28.9 was found.

Kuorinka and Koskinen [1979] found a significant difference in neck MSDs between scissor makers (an occupation chosen for study because of its assembly-line repetitive hand tasks) and shop assistants (non-stereotypic, non-repetitive jobs) with OR of 4.1. In the same study, comparing the different stereotypic, repetitive jobs in scissor-making, those in short-cycled tasks (2–9.5 sec) had no significantly different prevalence of neck disorders than workers in longer-cycled tasks (7.3–26 sec) (OR=1.6, 95% CI 0.7–3.8). It is important to note that both the longer-cycled tasks and short-cycled tasks in Kuorinka’s study would have been classified as “highly repetitive” in most other ergonomic studies. [Silverstein et al. 1987; Chiang et al. 1993; Viikari-Juntura et al. 1991; Kurppa et al. 1991.] When comparing two groups in which the level of repetitive exposure may not differ by much (in this case, where both groups have highly repetitive tasks), it is unlikely that one will find a significant difference, because there is not enough variance between the exposures.

Three studies [Ekberg et al. 1994, 1995; Milerad and Ekenvall 1990] used health

outcomes and exposure assessments based on self-reports and found significant associations between symptoms and repetitive work. The Ekberg studies specifically asked about “precise repetitive movements” in their questionnaire and controlled for confounders and effect modifiers (age, gender, having pre-school children) in their analyses. Milerad and Ekenvall [1990] compared dentists and pharmacists, stratified by gender, and found no association between neck or neck/shoulder MSDs with metabolic disease, smoking, leisure time, exposure, or vibration. Significant ORs of 2.0 to 2.6. for neck MSDs were reported for dentists compared to pharmacists.

Of those studies reporting no significant association between repetition and neck or neck/shoulder MSDs, none included exposure assessment or observations of the neck or neck/shoulder area that were both objective and independent of the hand/wrist. Several of these studies [Baron et al. 1991; Kiken et al. 1990; Hales et al. 1989; Ohlsson et al. 1989; Luopajarvi et al. 1979] categorized workers into high and low exposure groups based strictly on hand/wrist exposure and not arm, shoulder, or neck exposure. All of these studies reported ORs below 2.0.

In the study of video display terminal (VDT) users by Bergquist et al. [1995], exposure was based on self-reports of “the presence of repeated work movements” for all work tasks, and not specifically focused on the neck or neck/shoulder area. They found no significant association with neck/shoulder MSDs when the variable “repeated work movements” was analyzed in the logistic model alone, but found a significant relationship with a combination of variables:

(1) workers wearing glasses, (2) who reported VDT use, and (3) VDT use for more than 20 hours/week. In this case, it was the combination of variables at higher levels of exposure (VDT use more than 20 hours per week) that was found to be statistically significant.

Temporal Relationship—Repetition and Neck/Shoulder MSDs

Of the three prospective studies of neck MSDs that can be used to establish a temporal relationship between exposure to work factors and neck or neck/shoulder disorders, the study by Jonsson et al. [1988] fulfills all the four study criteria. Jonsson's study was a follow-up of the cohort studied by Kilbom et al. [1986], electronic workers who entered the study without MSDs. Exposure assessment pertaining specifically to the neck/shoulder area was completed three times over 3 years.

In the longitudinal study by Ohara et al. [1976], the authors attributed the increase in neck symptoms in cash register operators to the introduction of new electronic cash registers placed at unsuitable heights. They noted an increase in repetitiveness and an increase in awkward and static postures by cash register operators using the new registers. The authors reported a relationship between static loading and MSDs, and found that a subsequent reduction in exposure to static loading resulted in less worker disability (sick leave).

Although temporality cannot be obtained from cross-sectional studies, several studies attempted to insure that disorders developed following the exposure being studied. In certain studies [Baron et al. 1991; Kiken et al. 1990; Hales et al. 1994; Hoekstra et al.

1994], the health outcome definition excluded persons reporting symptoms prior to the job or reporting acute injury thought to be unrelated to work, insuring that exposure preceded MSD occurrence. Other studies excluded participants with less than 6 months (or even longer) of job experience, thereby omitting from their study workers who may have developed their MSDs prior to working at the job of interest, or who had experienced discomfort or fatigue due to new activities or a "break-in period" at work. It is reasonable to assume that in those studies, given the exclusions required by the case definitions, the onset of exposure was prior to the onset of neck/shoulder MSDs in the majority of participants.

Consistency in Association for Repetition and Neck/Shoulder MSDs

In the studies fulfilling the four criteria [Ohlsson et al. 1995; Jonsson et al. 1988; Kilbom et al. 1986], a positive association between neck MSDs and repetitive work was found, although ORs ranged from 1.6 to 7.5. Many more studies involved workers in repetitive work from a range of industries (VDT workers, dentists, electronic assembly, sewing machine operators, etc.), comparing symptom prevalences to those in less repetitive jobs. There was also significant association between neck and neck/shoulder MSDs and jobs with repetitive tasks, with ORs between 1.6 and 5.9 [Onishi et al. 1976; Kuorinka and Koskinen 1979; Rossignol et al. 1987; Vihma et al. 1982; Kamwendo et al. 1991; Anderson et al. 1993; Ekberg et al. 1994, 1995; Schibye et al. 1995] indicating that workers exposed to higher levels of work risk factors have greater rates of neck and neck/shoulder symptoms. None of the

studies that failed to find significant associations carried out exposure assessment of the neck or neck/shoulder.

Coherence of Evidence for Repetition

Studies outside the epidemiologic literature give supportive evidence that repetitive work is related to neck/shoulder disorders. In 1966, Stevens et al. found that the neck injuries among fork-lift truck drivers were from repetitive, extreme head rotations needed for operations of fork lift trucks, and introduced the sideways-sitting driver forklift. Eklund et al. [1994] reported following up on a “sideways-sitting” forklift (in an unpublished study); these drivers experienced neck pain three times as often as other drivers on traditional forklifts—indicating that moderate head rotations during long periods of time can be more risky than short term and extensive head rotations. Nicholas [1990] reported in his discussion on pathophysiologic mechanisms of sports injuries that a low-load force with high repetition results in a gradual deterioration of tissue strength from strain to fatigue to deformation, with prefailure symptoms, such as pain on use, a common clinical sign of early inflammation from overuse.

Exposure-Response Relationship for Repetition

There were no studies reviewed that showed a clear dose-response relationship between repetition and neck and neck/shoulder MSDs.

Conclusions Regarding Repetition

The association between neck or neck/shoulder MSDs and repetitive work was found to be statistically significant in 19

studies using different epidemiologic approaches and under different circumstances of exposure. Twenty-seven studies found odds ratios above one; of these, 13 were above 3.0. Almost all the studies (6 of 8) with non-significant associations used hand/wrist exposure assessments for their analyses and did not conduct specific neck, shoulder, or upper extremity (apart from hand/wrist) exposure assessment. (Only one of the studies finding significant associations did so using hand/wrist exposure assessment.) The possibility of misclassification affecting the results must be a consideration.

FORCE

Definition of Force for Neck and Neck/Shoulder MSDs

For our review, we included studies that examined force or forceful work or heavy loads to the neck and neck/shoulder, or described exposure as strenuous work involving the upper extremity that generates loads to the trapezius muscles. Most of the studies that examined force or forceful work as a risk factor for neck/shoulder had several concurrent or interacting physical work load factors.

Force has generally been defined as: (1) either externally as a load or internally as a force on a body structure, or (2) a force magnitude expressed in newtons or pounds or as a proportion of an individual's strength capacity, that is, of a person's maximal voluntary contraction (MVC), usually measured by EMG. Most studies that have dealt with force loading of the neck or stress generated on the neck structures are from biomechanical studies performed in the laboratory. These studies are not included in

this document. In the epidemiologic studies reviewed, force is usually estimated by either questionnaire, biomechanical models, in terms of weight lifted, electromyographic activity, or the variable, “heavy physical workload.”

Eighteen studies reported results on the association between force or forceful work (in combination with repetition) and neck and neck/shoulder MSDs. Of the 18 studies of force and neck MSDs, 12 found a statistically significant positive association between force and neck or neck/shoulder MSDs; six others had non-significant findings. In terms of magnitude of the association, two studies had ORs greater than 3.0, seven were between 1.0 and 3.0, and two were less than 1.0. Seven studies did not report their results in terms of ORs or prevalence rate ratios (PRRs) but reported that the findings were statistically significant at the $p < 0.05$ level.

Studies Meeting the Four Criteria for Force and Neck/Shoulder MSDs

There were no studies that met the four epidemiologic evaluation criteria for forceful exertion of the neck.

Studies Not Meeting the Four Criteria for Force and Neck/Shoulder MSDs

Åaras et al. [1994] carried out a cohort study of four groups, 15 female assembly workers making telephone exchanges, 27 female VDT users, 25 female data entry operators, and 29 male VDT users. Case definition for neck MSD was based on self-reports. However, musculoskeletal sick leave per man-labor years was also used as an endpoint. For force estimate the load on the

trapezius was measured by electromyography (EMG).

Quantification of the muscle load was done by ranking the interval estimate (0.1 s) to produce an amplitude probability distribution function. Both the total duration and number of periods per minute when muscle activity was below 1% maximum voluntary contraction (MVC) were calculated. Post-intervention (which involved changes to the workstation, tools, and organization of work)—see Table 2-4 at the end of the chapter for further explanation), the mean static trapezius load in assemblers was reduced from 4.3% MVC to 1.4%, the mean static trapezius load in VDT users reduced from 2.7% MVC to 1.6% MVC (post-intervention). Sick leave also decreased considerably. Because so many interventions were involved in this study, it is not clear to what intervention changes the decrease in sick-leave per man-labor years might be attributed.

Bjelle et al. [1981] compared 13 workers of an industrial plant consecutively seen at health clinic with acute, nontraumatic shoulder-neck pain not due to causative disease or malformation compared to 26 controls, matched on age, gender and place of work.

In another cohort study, Veiersted and Westgaard [1994] followed 30 female chocolate manufacturing workers, 17 of whom contracted trapezius myalgia within 6 to 51 weeks compared to those workers who did not. Diagnosis was based on both symptoms and physical exam. There were prospective interviews every 10 weeks to detect symptoms of muscle pain. Daily “pain diaries” were also kept by subjects.

Exposure assessment consisted of measured static muscle tension recorded by EMG. Interviews concerning exposure at work were also conducted prospectively every 10 weeks for 1 year. Only 55% of the subjects were retained during the full study; however, the 'drop-outs' were follow-up subjects and had no significant differences in static muscle tension compared to the participants.

Viikari-Juntura et al. [1994], the third longitudinal study discussed under force and neck and neck/shoulder MSDs, used questionnaire to assess neck symptoms and based exposure on job category, comparing 688 machine operators, 553 carpenters, and 591 office workers. For the initial evaluation, observation of work sites were performed. In multivariate analysis occupation, age, and current smoking were significant predictors in change from no neck trouble to severe neck trouble (ORs were not given for logistic model.)

Wells et al. [1983] evaluated letter carriers with an increased load on the shoulder from a mailbag. Letter carriers were compared to gas meter readers (without heavy loads) and postal clerks. A telephone survey was used to obtain both symptoms and exposure. This analysis was adjusted for age, number of years on the job, quetelet ratio and previous work experience.

Of the studies in the tables, three (that did not fulfill all the inclusion criteria) examined the risk factor, force, either as trapezius muscle load (using EMG), or as forceful work in combination with other risk factors [Åaras et al. 1994; Wells et al. 1983; Onishi et al. 1976]. Wells et al. [1983] found a significant difference ($p < 0.05$) in reported neck pain between letter carriers and postal

clerks and attributed it to weight from carrying heavy mail bags on shoulder straps. In the Wells study, confounding due to age, number of years on the job, previous work experience, or quetelet ratios was ruled out. As noted above, Onishi et al. [1976] reported that the operations studied required continuous contraction of the trapezius muscle to sustain the arms, estimated to be about 10 to 30% of the maximum contraction of the trapezius. This level, 10 to 30% of the maximum contraction, was found by Tanii et al. [1972] to induce static fatigue significant enough to produce electromyographic changes. Hales et al. [1989] and Kuorinka et al. [1979] reported statistically significant ORs (1.6 and 4.1, respectively) for the association between neck MSDs and high levels of force combined with high levels of repetition estimated for the hand/wrist areas. There were no separate force measurements for the neck area. Both studies controlled for age, gender, and length of employment in the current job. Two of the four studies that used estimated hand and wrist exposure measurement combinations of force and repetition (but carried out no neck, shoulder, or upper extremity exposure measurements) found non-significant associations between neck MSDs and force/repetition exposure [Baron 1991 et al.; Kiken et al. 1990].

Temporal Relationship—Force and Neck/Shoulder MSDs

See temporal relationship above in Repetition and Neck/Shoulder MSDs.

Consistency in Association for Force and Neck/Shoulder MSDs

Both Kilbom et al. [1986] in their cross-sectional study and Jonsson et al. [1988] in their follow-up cohort studies found that

“time spent in physically heavy work before the present employment” appeared as a strong risk factor for deterioration of health of the neck/shoulder area (specifically, the health outcome was for the cervicobrachial region in the Jonsson study). Jonsson et al. [1988] noted that the physical demands of the previous jobs had only been assessed at the initial interview and constituted a subjective estimate. However, the relationship was strengthened by the consistency of findings in the prospective and cross-sectional studies.

Coherence of Evidence for Force

There is coherence with the biological mechanisms proposed by Hagberg [1984] for occupational muscle-related disorders, such as tension neck syndrome. The first mechanism concerns stress on the trapezius and surrounding muscles of the neck from heavy physical exertion that causes rupture of the muscle's z-discs, and an outflow of metabolites from the muscle fibers, and activation of pain receptors through edema or other mechanisms. This temporary high, local stress involving eccentric contractions in the shoulders improves with time through a re-orientation of collagen in the muscles. This mechanism is offered as an explanation for MSDs in workers unaccustomed to the work. The second mechanism is from local decreased blood flow (ischemia), as seen in assembly workers whose tasks involved dynamic, frequent contractions above 10 to 20% of the MVC and few rest breaks. Reduced blood flow was found to be correlated with myalgia (muscle pain) and ragged red fibers in 17 patients with chronic myalgia thought to be associated with static load during repetitive assembly work [Larsson et al. 1990]. The third pathophysiologic mechanism for muscle

pain deals with energy metabolism disturbance, caused by long-term static contractions of the muscles. Supporting this theory was a study finding a correlation between muscle tension and plasma myoglobin among patients with regional muscle tenderness and pain [Dannesheold-Samsoe et al. 1983].

Other laboratory studies have examined muscle damage that may arise during static muscle contractions used to maintain static postures. Hägg et al. [1990] proposed that while maintaining static postures (that have low force levels), the same low-threshold motor units are contracted repeatedly for prolonged periods, during which time they work close to their maximal capacity. This may lead to injury of these units, despite the fact that the total workload is low. This hypothesis was recently supported by a longitudinal study by Veiersted et al. [1993] who investigated the number of rest-pauses during muscle fiber activity using EMG recording from neck and shoulder muscles. Among subjects performing machine-paced repetitive packing work, those with symptoms had fewer rest-pauses (0.9 versus 8.4 per minute) and a tendency toward shorter total duration of rest-pauses in the muscle fiber activity of their trapezius muscle when compared with those without symptoms. These mechanisms of decreased blood flow, increased metabolite concentration, and prolonged activation of certain small units at near maximum capacity may explain the chronic myofascial shoulder pain seen in workers performing repetitive assembly work with static loading of the trapezius muscles [Hagberg and Kvarnstrom 1984; Larson et al. 1988].

Exposure-Response Relationship for Force

Aarås et al. [1994] reported that by reducing static muscle loading (an indication of force measurement) through equipment changes among VDT users, as well as improving workplace organization, he was able to decrease the prevalence of neck pain, decrease the number of sick days taken, and cause a significant reduction in trapezius load measured by EMG in VDT operators.

Conclusions Regarding Force

There is evidence for forceful exertion and neck MSDs in the epidemiologic literature. Most of the epidemiologic studies reviewed defined “forceful work” for the neck/shoulder as work activities that involve forceful arm or hand movements that, in turn, generate the loads to the neck/shoulder area; no study examined a relationship based on actual forceful neck movements. Of the 17 studies addressing force as one of the exposure factors, 5 found statistically significant associations but did not derive ORs; 2 found ORs greater than 3.0, 7 found ORs from 1 to 3.0, and 2 studies showed ORs less than 1.0. Many of the studies regarding measured force (as workload, etc.) and MSDs are in the biomechanical and ergonomic literature.

POSTURE

Definition of Posture for Neck and Neck/Shoulder MSDs

We included those articles that mentioned neck or head postures, adverse or extreme head or neck postures, or static postures of the head and/or neck.

Studies Reporting on Posture as a Work Factor for Neck and Neck/Shoulder Musculoskeletal Disorders

We included 31 studies of the association between extreme or static posture and neck and neck/shoulder MSDs, including TNS. Studies usually focused on the different prevalences of neck symptoms and/or physical findings in workers in occupations or tasks requiring some combination of forceful, repetitive movements, and extreme or static postures of the upper extremity, and compared them to workers in occupations without those requirements.

Twenty-seven studies that considered extreme or static posture found a statistically significant positive association between posture and neck or neck/shoulder MSDs; three had non-significant findings (Table 2-1). Overall, in terms of magnitude of the association, looking at both significant and non-significant findings, 13 studies had estimations of risk (ORs or PRRs) greater than 3.0, 9 had risk estimates between 1 and 3, and none had an estimate less than 1.0. Eleven studies did not report their results in terms of ORs or PRRs; of these, all but one found a significant relationship.

Studies Meeting the Four Evaluation Criteria

Of the 31 studies evaluating neck postures and neck MSDs, the three investigations mentioned above [Ohlsson et al. 1995; Jonsson et al. 1988; Kilbom et al. 1987, 1986] fulfilled the four evaluation criteria. Three of these studies [Jonsson et al. 1988; Kilbom et al. 1986, 1987], dealt with the same cohort; female electronics workers

followed for 3 successive years. These studies found significant association between posture variables and neck MSDs; however, none used methods that reported ORs.

Studies Not Meeting the Four Criteria for Posture and Neck/Shoulder MSDs

Bernard et al. [1991] carried out a cross-sectional study of 894 newspaper employees using a questionnaire survey for case definition based on frequency, duration, and intensity of symptoms in the neck. Exposure was based upon both questionnaire and job analysis. Time spent on the telephone was associated with an increased prevalence of neck MSDs, with a slightly elevated OR of 1.4. Analysis was controlled for age, gender, height, psychosocial factors, and medical conditions.

Kukkonen [1983] compared 104 data entry operators with 57 female workers in varying office tasks. Neck MSD was based on pre-determined symptom and physical exam. Exposure was based on observation of posture, movements and working techniques, assessment of equipment, interview with workers and supervisors. An intervention consisting of adjustment of office furniture and equipment was carried out. The study group was given a short course of basic training on pertinent aspects of ergonomics. Four lessons on relaxation was given by means of exercises. There was no controlling of confounders. There was a significant decrease in tension neck syndrome among the cases involved in the intervention compared to those workers who had no change.

Linton and Kamwendo [1991] surveyed 22,180 employees undergoing screening examinations at their occupational health

care service in Sweden. Neck cases defined from questionnaire responses as those persons reporting "yes" to having seen a health care professional for neck pain in the last year. Cases were compared to "non-cases" defined by outcome (neck pain). Exposure was based on questionnaire responses regarding heavy lifting, monotonous or assembly line work, sitting, uncomfortable work postures (bending and twisting), and vibration. The psychosocial work environment was also studied; the analysis was stratified for age and gender.

As part of a longitudinal study, Viikari-Juntura [1994] studied 154 subjects from Helsinki, Finland that originally entered the study in 1955, and had repeated cross-sectional exams from 1961 to 1963. During that time, 1084 subjects underwent cross-sectional examination. In 1985, a questionnaire was sent to all subjects; 801 (74%) responded. Of the respondents, 180 lived in the Helsinki area. It was from this group that 162 responded. Eight were excluded due to illnesses. Outcome was based on questionnaire data for this study — because of small number of abnormal physical findings, the P.E. was eliminated from analysis. Exposure was also based on survey, asking the amount of work with hands overhead, work in forward bent position, and work in twisted or bent position. This analysis was controlled for physical and creative hobbies, with no interactions seen.

In a cross-sectional study of machine operators, carpenters were compared to office workers by Tola et al. [1988], who used a postal questionnaire to obtain both health outcome and exposure information. Analysis used "occupation" to examine relationships. Pain Drawing Diagrams were

used to distinguish body areas. For the logistic regression model a 12 month prevalence of neck and shoulder symptoms on 8 days or more was used. The logistic regression models were adjusted for years working in an occupation and age.

Welch et al. [1995] examined 39 electricians at a screening convention using surveys to collect information on symptoms and exposures. The questionnaire included questions concerning the frequency of tasks performed, including the percent of time spent hanging duct work. The analysis did not control for confounders except for length of employment.

Strength of Association for Posture

Ohlsson et al.'s [1995] study, discussed previously, compared female industrial workers performing repetitive tasks to referents without such exposure and found significant associations ($p < 0.05$) between (1) neck and neck/shoulder diagnoses with time spent in neck flexion, with critical angles greater than 15° ; and (2) neck/shoulder diagnoses and time spent with upper arm abduction greater than 60° .

Kilbom et al. [1986], in the initial paper concerning the electronic workers, reported two findings: (1) that the more dynamic the working technique, the fewer neck symptoms experienced by electronic workers; and (2) that the greater the average time per work cycle spent in neck flexion, the greater the association with symptoms in the neck and neck/shoulder angle. A statistically significant association ($p < 0.05$) was also obtained from the job analysis variables describing neck forward flexion and upper arm elevation and neck and neck/shoulder disorders. Jonsson et al.

[1988], in the follow-up study, performed an analysis that grouped the different parts of the neck and upper extremity into a health outcome labeled "cervicobrachial disorder" (unlike the cross-sectional study by Kilbom et al. [1986] that used "neck" and "shoulder"). They found that the relationships between MSDs and neck forward flexion, upper arm elevation, and cervicobrachial disorders weakened (compared with the results that Kilbom et al. [1986] had found), but that the results still remained statistically significant in some of the multifactorial analyses (no numerical results were reported). The most important finding, according to the authors, was that reallocation to more varied work tasks was a strong predictor of improvement over the second year. This change would have decreased static loading and increased the dynamic pattern of movements of the workers.

Of those studies not fulfilling the four criteria, results regarding extreme or static posture were similar to those of the studies which did fulfill them. Sakakibara et al. [1995] found a significant difference in the prevalence of neck MSDs when they examined orchard workers who picked and bagged pears and two months later picked and bagged apples. Exposure was assessed by job analysis and posture measurements of two representative workers. Arm and neck elevation was significantly greater for bagging pears (more than 90° for 75% of the time) than for bagging apples (less than 40% of the time). The same authors found similar results in 1987 when only the symptoms of orchard workers were studied. They found significant a positive association between posture and neck MSDs, reporting histograms (not ORs) in their article.

Although they did not mention the participation rates in their methods, Ååras et al. [1994], Veiersted et al. [1994], and Bjelle et al. [1981] found significant relationships between postures and neck MSDs (they fulfilled the other three criteria). Veiersted [1994] found an association between "perceived strenuous postures" and neck MSDs (OR = 7.2), but found that these perceived postures were not reflected in any of the conventional EMG parameters (static, median or peak loads) measured in the participants. One explanation for these results may be information bias, if the data concerning perceived strenuous posture are from questionnaires. Another explanation may be that EMG testing results reflect parameters for a single day, whereas symptoms were asked about concerning the entire previous year.

Several studies that carried out no independent assessment of ergonomic factors, but relied on self-reported exposure found significant relationships between posture variables and neck disorders. Ekberg et al. [1995] found an OR of 4.8 for the variable "work with lifted arms," and an OR of 3.6 for "uncomfortable sitting position" and neck MSDs. Hales et al. [1994] found that "use of bifocals" (OR=3.8) in VDT users was significantly associated with neck MSDs; this variable was interpreted to be a surrogate for neck posture, as bifocals require either neck flexion or extension for eye accommodation when viewing a VDT screen. Bernard et al. [1994] reported that as workers' time spent on the telephone increased, so did the ORs for neck symptoms, and interpreted this variable as a surrogate for static posture requiring neck deviation to cradle the telephone receiver. Holmström et al. [1992] found that the odds of workers with neck MSDs reporting

working with hands above their shoulders for greater than 4 hrs/day compared with those reporting less than 1 hr/day was 2.0, a statistically significant finding. Bergquist et al. [1995] reported an OR of 4.4 for workers using highly placed keyboards in their logistic modeling of neck MSDs. Kuorinka and Koskinen [1979] found an increased OR (4.1) of neck MSDs for scissor makers (chosen for their stereotypic, repetitive work using extreme postures) compared to shop assistants, although no quantitative measurements or observations of neck posture were reported. One study by Hunting et al. [1981] showed a fairly strong association (OR = 4.9) with constrained postures and neck MSDs in those workers having neck flexion of more than 56°. Several articles with significant posture and neck MSD associations dealt with comparisons of workers in occupations chosen for higher observed combinations of exposure factors and compared them to workers with fewer observed exposure stressors: Viikari-Juntura et al. [1994], OR=3.9 to 4.2; Milerad and Ekenvall [1990], OR=2.6; and Wells et al. [1983], OR=2.6.

For those studies that did not find a significant relationship, 2 out of the 3 did not carry out observation or measurement (ergonomic assessment) of the neck or upper extremity postures. Ferguson [1976] stated that seven body dimensions were measured in the telephonists studied, but that neither discomfort nor aching were linked with any of these body postures. The article does not mention the body postures that were measured. Ferguson's conclusion, that "physical complaints in telephonists are probably due to static load on joints and muscles occasioned by the fixed forward bent position determined by visual, auditory

and manipulative tasks." Ferguson's data are contrary to the conclusions presented. These conclusions may then only be speculative.

Temporality for Extreme or Static Postures

The prospective study by Veiersted and Westgaard [1994] followed the development of trapezius myalgia among 30 female chocolate manufacturing workers. Seventeen workers developed the MSD within 6 to 51 weeks of starting work. Perceived strenuous postures on the assembly line were found to contribute to the disorders. Although retention of subjects was low (55%), the authors found that the "drop-outs" did not differ in exposure estimates and symptom reporting from those retained in the study. The prospective study of Viikari-Juntura et al. [1994] used self-reported symptoms and exposure defined by occupational status to find a temporal relationship between the development of severe and persistent severe neck pain and jobs involving dynamic work, static posture, and whole body vibration, as compared to office work.

Consistency in Association for Extreme or Static Postures and Neck/Shoulder MSDs

Of the 31 studies we reviewed reporting results on the association between specific or static posture and neck and neck/shoulder MSDs, 28 found statistically significant associations. There were many different studies reporting ORs of greater than 3.0 with CIs above 1, indicating that the effects were not explained by chance. Consistent associations were also found in those studies dealing with specific postures and neck MSDs across many industries, from fish workers [Ohlsson et al. 1995] to fruit pickers [Sakakibara et al. 1995], to assembly line

workers [Jonsson et al. 1988], to garment workers [Vihma et al. 1982; Anderson and Gaardboe 1993].

Coherence of Evidence for Extreme Or Static Postures

See section above under Coherence of Evidence for Force.

Exposure-Response Relationship for Specific or Static Postures

The study by Ohara et al. [1976], mentioned earlier, not only portrayed the multifactorial nature of neck and shoulder MSDs, but documented that an increase in specific and static postures by cash register operators using new registers placed on unsuitable counter heights increased symptoms in neck MSDs.

Several studies have suggested an exposure-response effect between increased level or duration of exposure and an increase in number of cases of neck MSDs. Burt et al. [1990], in their investigation at a major urban newspaper, found that an increase in the self-reported percentage of time spent typing at VDT keyboards was associated with a moderate increase in neck symptoms. (Job analysis found a significant relationship between independent observation of time spent typing and self-reported time) Keyboard time was considered by the authors to be a surrogate for time spent with the neck held in static postures with arms unsupported. Rossignol et al. [1987] found that the prevalence of neck symptoms among 1,545 clerical workers increased with the number of hours per day using VDTs. Knave et al. [1985] found that, among VDT operators, total daily working hours and time spent at the VDT screen were significant risk factors for neck pain.

Anderson and Gaardboe [1993] found an exposure-response relationship between persistent neck pain and years of being a sewing machine operator, controlling for age.

Conclusions Regarding Extreme or Static Postures

Overall, the strength of the association (OR ranging from about 1.6 [Vihma 1982] to 7 [Veiersted 1994], dropping the outliers) between specific postures and neck MSDs was similar between studies using the most restrictive criteria and carrying out a prospective design and those that used symptom-based health outcome or self-reported exposures to static or specific postures and cross-sectional methods. We conclude that there is *strong evidence* for support of an association between static or specific postures and neck and neck/shoulder MSDs based on strength of association criteria. A positive relationship has been observed between exposure to this risk factor and neck or neck/shoulder MSDs in studies where chance, bias, and confounding can be ruled out with reasonable confidence.

VIBRATION

No study of neck MSDs met the four criteria to address strength of association between vibration and neck MSDs and only one of the reviewed studies in the tables mentioned neck MSDs and vibration. Viikari-Juntura et al. [1994] selected study groups for their longitudinal study based on different work exposures. Machine operators exposed to static work and whole-body vibration were compared to carpenters exposed to dynamic physical work and presumably no vibration to see whether occupational status was related to neck MSDs. Results found that the

OR for progressing from no neck pain to moderate to severe neck trouble was from 3.9 to 4.2; for operators compared to carpenters; a significant difference. No vibration measurements were performed in this study, and vibration was likely to be confounded by neck twisting and static loads.

Conclusions—Vibration and Neck or Neck/Shoulder MSDs

We conclude that there is *insufficient evidence* to support an association between vibration and neck or neck/shoulder MSDs based on strength-of-association criteria. Too few studies of neck or neck/shoulder MSDs have examined the relationship between exposure to vibration and to draw any conclusions about their relationship.

NECK OR NECK/SHOULDER MSDs AND THE ROLE OF CONFOUNDERS

As in many MSDs, prevalence of neck and neck/shoulder disorders tends to increase with age. Therefore, it is important that studies take into account when examining the strength of occupational versus non-occupational factors. Age and gender were the primary potential confounders that investigators addressed in many of the studies on neck and neck/shoulder MSDs (The tables at the end of the chapter list summaries of each of the articles and include which particular covariates or confounders were considered.) These were either dealt with by logistic regression modeling, as in the case of age (e.g., Andersen and Gaardboe [1993]; Rossignol et al. [1987]; Tola et al. [1988]; Ohlsson [1989]; Baron et al. [1991]), through matching of case subjects and referents (e.g., Vihma et al. [1982]), or through study of a single gender (e.g., Luopajarvi et al. [1979];

Hunting et al. [1994]), or stratifying by gender [Sakakibara et al. 1995]. Most studies performed univariate analysis prior to logistic regression to consider factors which needed to be introduced into the logistic models as confounders or covariates.

Almost all the studies we reviewed accounted for the confounders of age and gender. Many of the studies controlled for leisure exercises [Andersen and Gaardboe [1993] smoking (Linton [1991]; Milerad and Ekenwall [1990]; Bergquist et al. [1995]; Viikari-Juntura et al. [1994]), medical conditions [Bernard et al. [1994]; Hales et al. [1994]). Reviewing the methods and results of these studies, the confounding factors do not account for the consistent relationship that is found with the work-related factors.

CONCLUSIONS

Interpreting association for individual workplace factors is difficult, as most epidemiologic studies of MSDs used populations selected because of multiple factors (such as forceful exertion and repetitive tasks). Unlike laboratory experiments, one cannot isolate exposure factors, nor alter some factors while keeping others constant to insure accuracy in examining, recording, and interpreting results. However, one can examine the body of epidemiologic evidence and infer relationships. There have been over 40 epidemiologic studies which have examined work factors and their relationship to neck and neck/shoulder MSDs. Many studies identified individuals in heavier industrial occupations and compared them to workers in light industry or office environments. Other studies identified a symptomatic group of workers, or those with symptoms and physical exam abnormalities, and compared them to asymptomatic workers at the same worksite, or to population

referents, and looked for differences in exposure. These approaches, although quite different, by and large have chosen to focus on similar workplace risk factors. These include repetition, forceful exertions, and constrained or static postures, usually found in combination.

There is also reasonable evidence for a causal relationship between highly repetitive work and neck and neck/shoulder MSDs. Most of the epidemiologic studies reviewed defined “repetitive work” for the neck as work activities which involve continuous arm or hand movements which affect the neck/shoulder musculature and generate loads to the neck/shoulder area; fewer studies examined relationships based on actual repetitive neck movements. The two studies which measured repetitive neck movements by head position (using frequency and duration of movements), and fulfilled the four criteria, found strong associations with neck/shoulder MSDs. In those studies defining repetitive work as continuous arm or hand movements affecting the neck/shoulder, nine studies found statistically significant ORs greater than 3.0. Eight studies fulfilled all the criteria except for objective exposure assessment and measured repetition for the hand/wrist, not the neck. Of these, three had statistically significant ORs greater than 3, and five had non-significant ORs, all under 2.0.

There is reasonable evidence for forceful exertion and neck MSD found in the epidemiologic literature. Most of the epidemiologic studies reviewed defined “forceful work” for the neck/shoulder as work activities which involve forceful arm or hand movements which generate the loads to the neck/shoulder area; no study examined a relationships based on actual forceful neck movements. Of the 17 studies

addressing force as one of the exposure factors, five studies found statistically significant associations but did not derive ORs; two studies found ORs greater than 3.0, seven studies from 1 to 3.0, and 2 studies with ORs less than 1.0.

There is **strong evidence** that working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck/shoulder muscles are at increased risk for neck/shoulder MSDs. Consistently high ORs (12 studies found statistically significant ORs over 3.0) for tension neck syndrome associated with static postures or static loads have been found.

The epidemiologic data are **insufficient** to document relationship of vibration and neck disorders. The few prospective studies which have included interventions to decrease workplace risk factor exposures, including decreasing repetitive work and less extreme working postures have shown a decrease in incidence of neck MSDs, and an improvement in symptoms among affected workers. These data provide additional evidence that these disorders are related to work factors.

However, cumulative exposure-response data is lacking, although VDT studies using surrogate exposure variables suggests a relationship.

Table 2-1. Epidemiologic criteria used to examine studies of neck MSDs associated with repetition

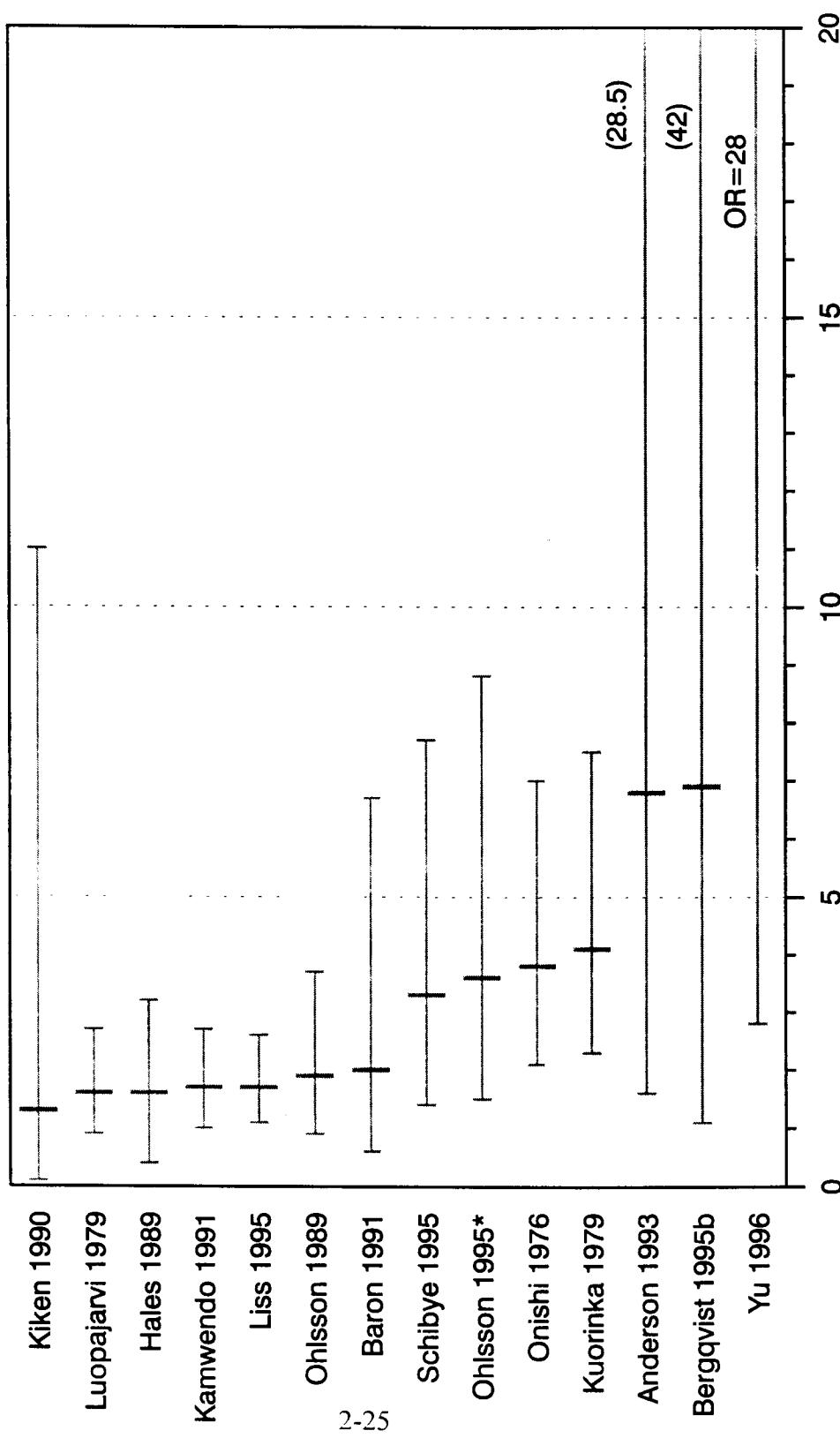
Study (first author and year)	Risk indicator (OR, PRR, IR or p-value)*,†	Participation rate ≥ 70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck exposure to repetition
Met all four criteria:					
Ohlsson 1995	3.6†	Yes	Yes	Yes	Observation or measurements
Met at least one criteria:					
Andersen 1993b	6.8†	Yes	Yes	Yes	Job titles or self-reports
Baron 1991	2.0	No	Yes	Yes	Job titles or self-reports
Bergqvist 1995b	6.9†	Yes	Yes	Yes	Job titles or self-reports
Hales 1989	1.6	Yes	Yes	Yes	Job titles or self-reports
Kamwendo 1991	1.65†	Yes	No	NR‡	Job titles or self-reports
Kiken 1990	1.3	Yes	Yes	Yes	Job titles or self-reports
Knave 1985	NR†	Yes	No	NR	Job titles or self-reports
Kuorinka 1979	4.1†	Yes	Yes	NR	Job titles or self-reports
Luopajarvi 1979	1.6	Yes	Yes	Yes	Job titles or self-reports
Onishi 1976	3.8†	NR	Yes	NR	Observation or measurements
Sakakibara 1987	NR†	Yes	No	NR	Job titles or self-reports
Schibye 1995	3.3†	Yes	No	Yes	Job titles or self-reports
Yu 1996	28.9†	Yes	No	NR	Job titles or self-reports
Met none of the criteria:					
Liss 1995	1.7†	No	No	No	Job titles or self-reports
Ohlsson 1989	1.9	NR	No	NR	Job titles or self-reports

*Some risk indicators are based on a combination of risk factors—not on repetition alone (i.e., repetition plus force, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

**Figure 2-1. Risk Indicator for "Repetition" and Neck Musculoskeletal Disorders
(Odds Ratios and Confidence Intervals)**



* Studies which met all four criteria

Note: Some studies indicate statistical significant association without a risk indicator. See Table 2a-1.

Table 2-2. Epidemiologic criteria used to examine studies of neck/shoulder MSDs associated with repetition

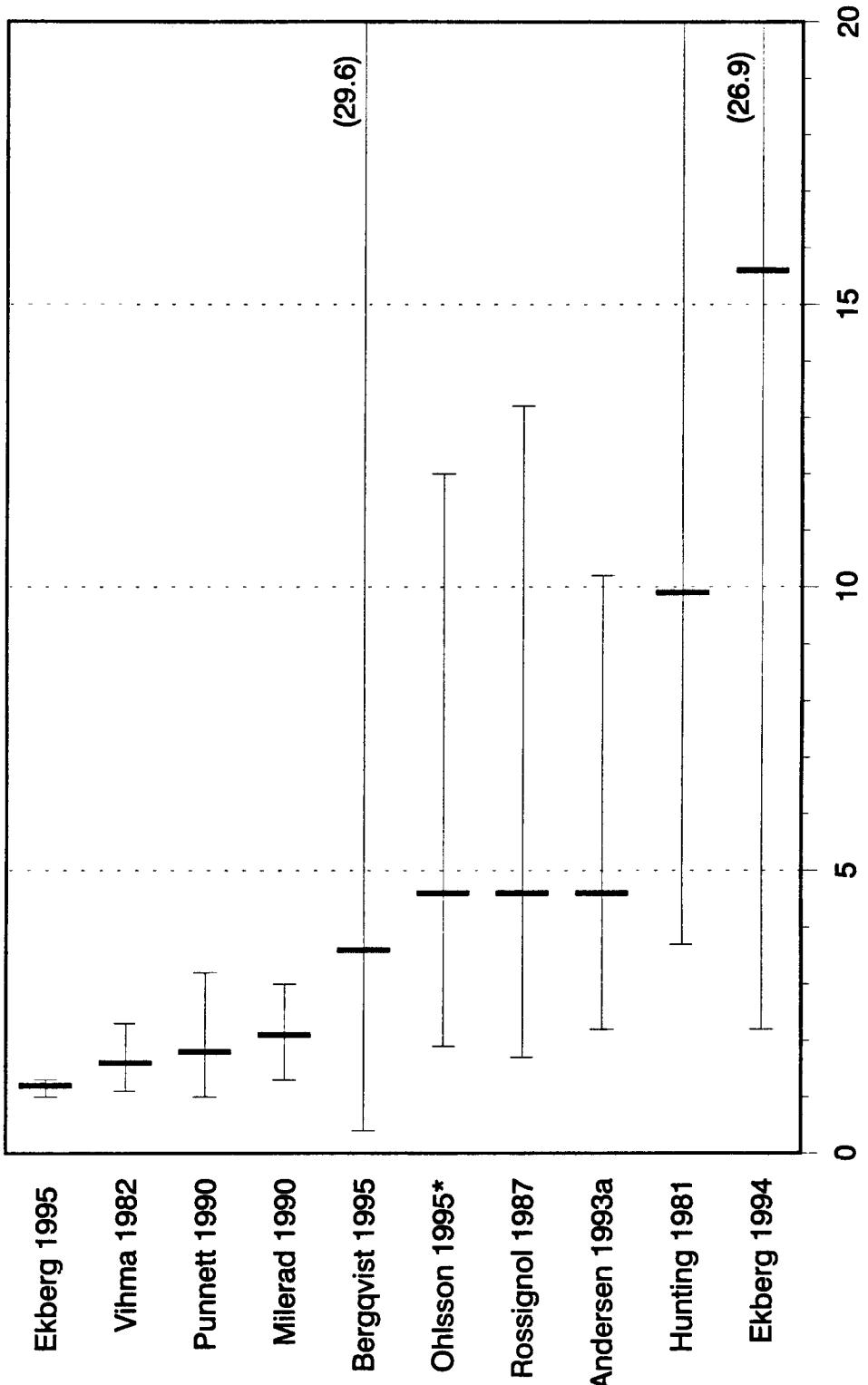
Study (first author and year)	Risk indicator (OR, PRR, IR or p-value)*,†	Participation rate ≥70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck/shoulder exposure to repetition
Met all four criteria:					
Jonsson 1988	NR†,‡	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	4.6†	Yes	Yes	Yes	Observation or measurements
Met at least one criteria:					
Andersen 1993b	4.6†	Yes	Yes	Yes	Job titles or self-reports
Bergqvist 1995a	3.6	Yes	No	Yes	Observation or measurements
Blåder 1991	NR†	Yes	Yes	No	Job titles or self-reports
Ekberg 1994	15.6†	Yes	No	NR	Job titles or self-reports
Ekberg 1995	1.2†	Yes	No	Yes	Job titles or self-reports
Hünting 1981	9.9†	NR	Yes	NR	Observation or measurements
Milerad 1990	2.1†	Yes	No	NR	Job titles or self-reports
Punnett 1990	1.8	Yes	No	NR	Observation or measurements
Rossignol 1987	1.8–4.6†	Yes	No	NR	Job titles or self-reports
Vihma 1982	1.6†	NR	No	NR	Observation or measurements

*Some risk indicators are based on a combination of risk factors—not on repetition alone (i.e., repetition plus force, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

Figure 2-2. Risk Indicator for "Repetition" and Neck/Shoulder Musculoskeletal Disorders
 (Odds Ratios and Confidence Intervals)



* Studies which met all four criteria
 Note: Some studies indicate statistical significant association without a risk indicator. See Table 2b-1.

Table 2-3. Epidemiologic criteria used to examine studies of neck MSDs associated with force

Study (first author and year)	Risk indicator (OR, PRR, IR or p-value)*,†	Participation rate ≥ 70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck exposure to force
Met at least one criteria:					
Baron 1991	2.0	No	Yes	Yes	Job titles or self-reports
Hales 1989	1.6 [†]	Yes	Yes	Yes	Job titles or self-reports
Kiken 1990	1.3	Yes	Yes	Yes	Job titles or self-reports
Kuorinka 1979	4.1 [†]	Yes	Yes	NR [‡]	Job titles or self-reports
Luopajarvi 1979	1.6	Yes	Yes	Yes	Job titles or self-reports
Veirested 1994	6.7 [†]	No	Yes	NR	Observation or measurements
Viikari-Juntura 1994	NR [†]	Yes	No	Yes	Job titles or self-reports
Wells 1983	2.6 [†]	Yes	No	NR	Job titles or self-reports
Met none of the criteria:					
Liss 1995	1.7 [†]	No	No	No	Job titles or self-reports

* Some risk indicators are based on a combination of risk factors—not on force alone (i.e., force plus repetition, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

† Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡ Not reported.

**Figure 2-3. Risk Indicator for "Force" and Neck Musculoskeletal Disorders
(Odds Ratios and Confidence Intervals)**

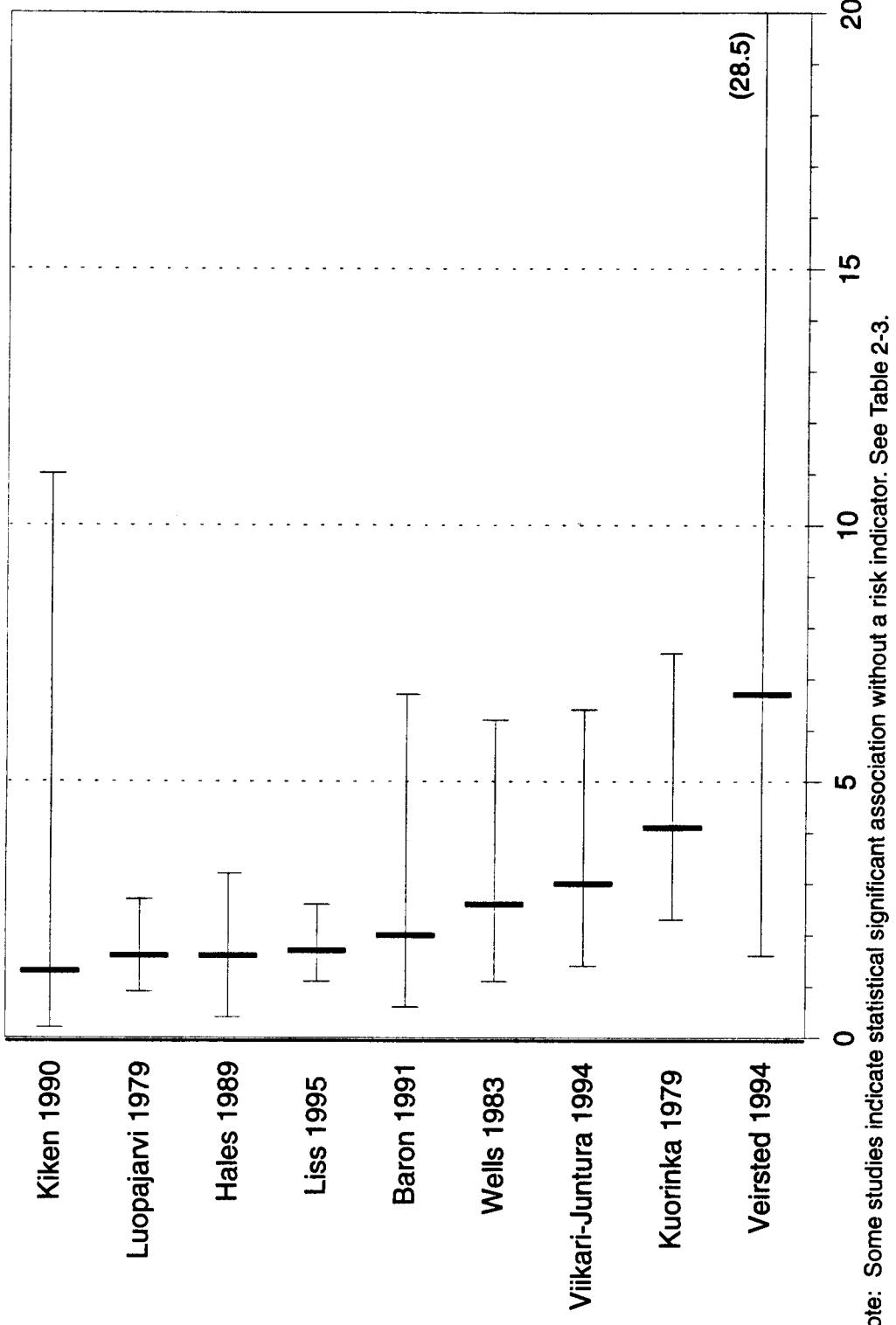




Table 2-4. Epidemiologic criteria used to examine studies of neck/shoulder MSDs associated with force

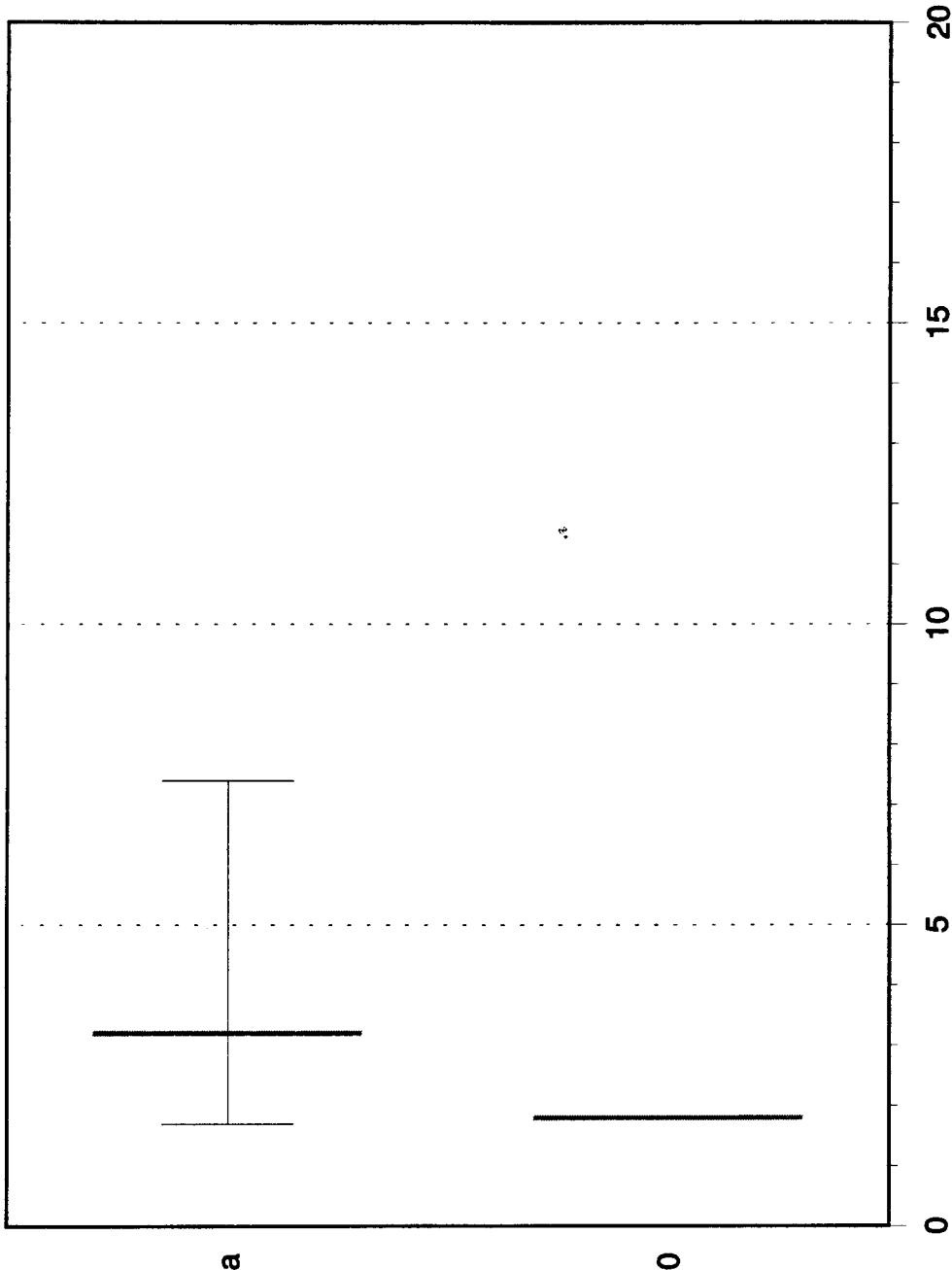
Study (first author and year)	Risk indicator (OR, PRR, IR or p-value)*,†	Participation rate ≥70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck/shoulder exposure force
Met at least one criteria:					
Aåras 1994	NR†,‡	NR	No	NR	Observation or measurements
Andersen 1993b	0.32	Yes	Yes	Yes	Job titles or self-reports
Bjelle 1981	NR†	NR	Yes	NR	Observation or measurements
Jonsson 1988	NR†	Yes	Yes	Yes	Job titles or self-reports
Punnett 1991	0.9 (females)	Yes	No	NR	Observation or measurements

*Some risk indicators are based on a combination of risk factors—not on force alone (i.e., force plus repetition, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

**Figure 2-4. Risk Indicator for "Force" and Neck/Shoulder Musculoskeletal Disorders
(Odds Ratios and Confidence Intervals)**



Note: Some studies indicate statistical significant association without a risk indicator. See Table 2-4..

Table 2-5. Epidemiologic criteria used to examine studies of neck MSDs associated with posture

Study (first author and year)	Risk indicator (OR, PRR, IR or p-value) ^{*,†}	Participation rate ≥70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck exposure to posture
Met at least one criteria					
Bernard 1994	1.4 [†]	Yes	No	Yes	Job titles or self-reports
Ferguson 1976	NR [‡]	Yes	No	No	NR
Hales 1994	3.8 [†]	Yes	Yes	Yes	Job titles or self-reports
Kamwendo 1991	1.65 [†]	Yes	No	NR	Job titles or self-reports
Kukkonen 1983	3.6 [†]	NR	Yes	Yes	Job titles or self-reports
Kuorinka 1979	4.1 [†]	Yes	Yes	Yes	Job titles or self-reports
Linton 1991	3.5 [†]	Yes	No	NR	Job titles or self-reports
Onishi 1976	3.8 [†]	NR	Yes	NR	Observation or measurements
Sakakibara 1987	NR [†]	Yes	No	NR	Observation or measurements
Sakakibara 1995	1.5	Yes	Yes [§]	NR	Observation or measurements
Veirested 1994	7.2 [†]	No	Yes	NR	Observation or measurements
Viikari-Juntura 1994	3.9–4.2 [†]	Yes	No	Yes	Job titles or self-reports
Welch 1995	7.5	Yes	No	No	Job titles or self-reports
Wells 1983	2.57 [†]	Yes	No	NR	Job titles or self-reports
Yu 1996	784.4 [†]	Yes	No	NR	Job titles or self-reports

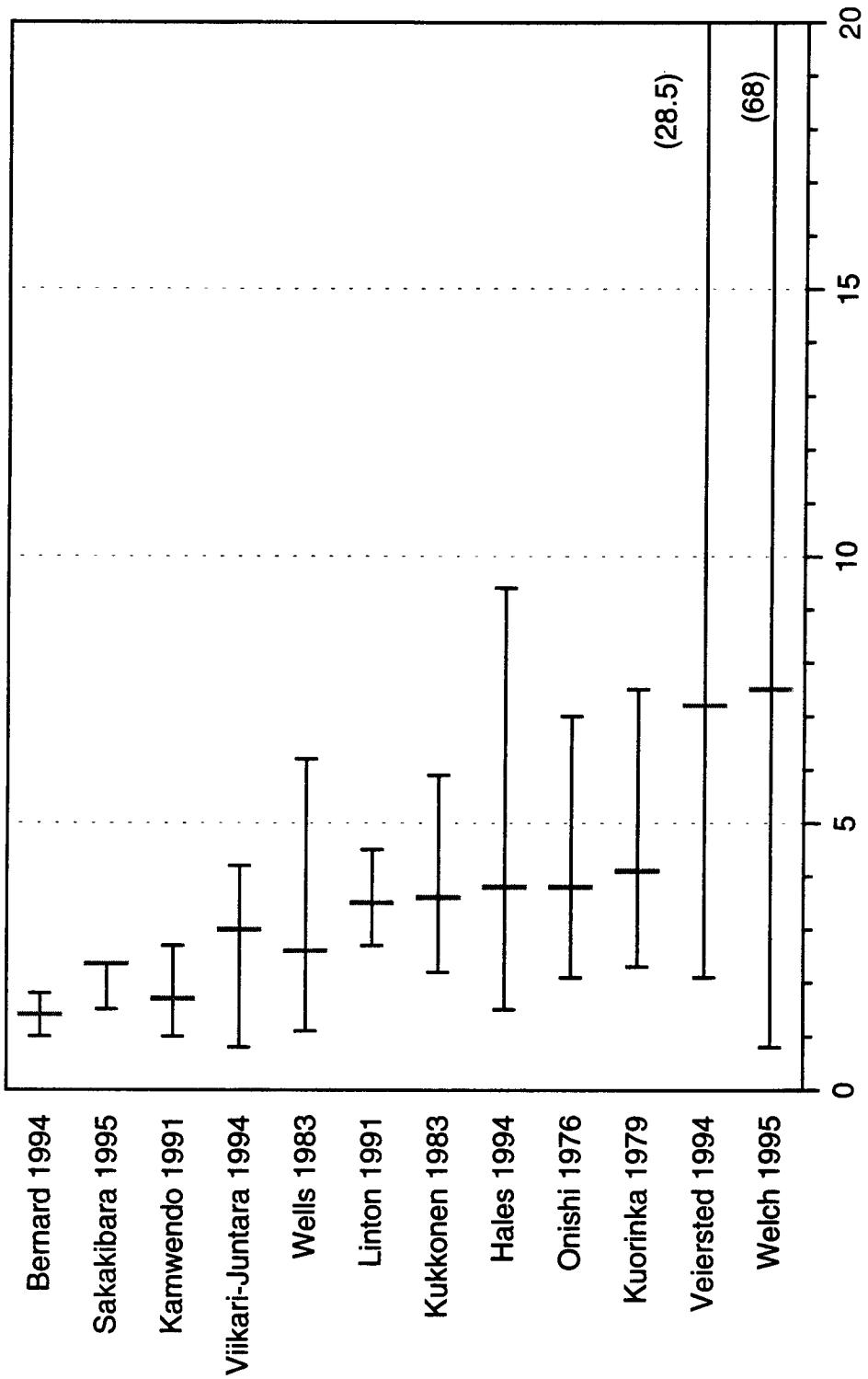
* Some risk indicators are based on a combination of risk factors—not on posture alone (i.e., posture plus force, repetition, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

§Physical examinations were not analyzed because there were too few cases.

**Figure 2-5. Risk Indicator for "Posture" and Neck Musculoskeletal Disorders
(Odds Ratios and Confidence Intervals)**



Note: Some studies indicate statistical significant association without a risk indicator. See Table 2-5.

Table 2-6. Epidemiologic criteria used to examine studies of neck/shoulder MSDs associated with posture

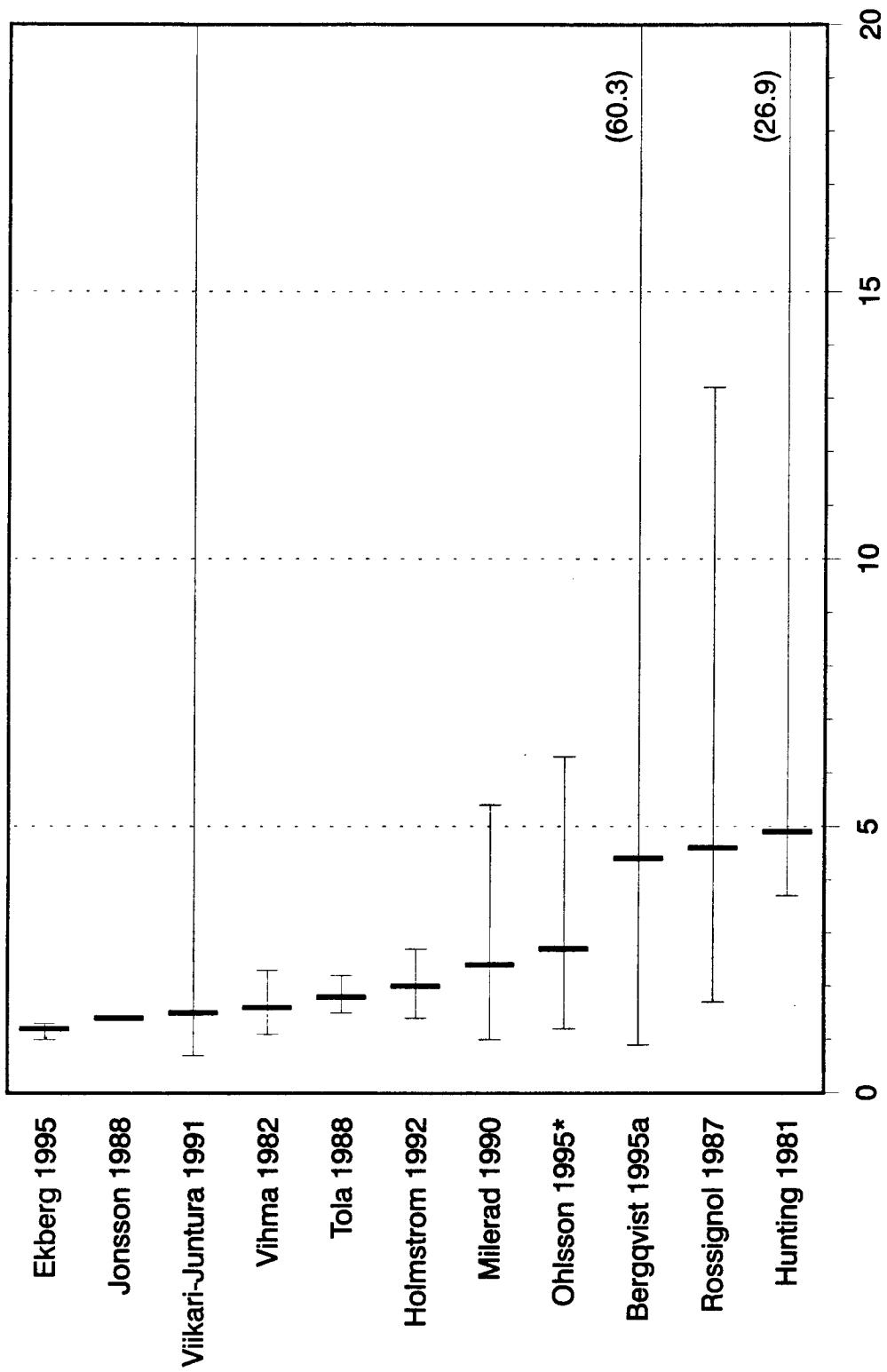
Study (first author and year)	Risk indicator (OR, PRR, IR or p-value)*,†	Participation rate ≥70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck/shoulder exposure to posture
Met all four criteria:					
Jonsson 1988	NR†,‡	Yes	Yes	Yes	Observation or measurements
Kilbom 1986	NR†	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	NR†	Yes	Yes	Yes	Observation or measurements
Ryan 1988	NR†	Yes	Yes	Yes	Observation or measurements
Met at least one criteria					
Aåras 1994	NR†	NR	No	NR	Observation or measurements
Bergqvist 1995a	4.4†	Yes	Yes	Yes	Job titles or self-reports
Bjelle 1981	NR†	NR	Yes	NR	Observation or measurements
Blåder 1991	NR†	Yes	Yes	No	Job titles or self-reports
Ekberg 1995	4.8† 3.6†	Yes	No	NR‡	Job titles or self-reports
Holmström 1992	2.0†	Yes	No	Yes	Job titles or self-reports
Hunting 1981	4.9†	NR	Yes	NR	Observation or measurements
Milerad 1990	2.6†	Yes	No	NR	Job titles or self-reports
Rossignol 1987	1.8, 4.0, 4.6†	Yes	No	NR	Job titles or self-reports
Tola 1988	1.8†	Yes	No	NR	Job titles or self-reports
Vihma 1982	1.6†	NR	No	NR	Observation or measurements
Viikari-Juntura 1991	1.5	Yes	Yes§	NR	Job titles or self-reports

*Some risk indicators are based on a combination of risk factors—not on posture alone (i.e., posture plus force, repetition, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

**Figure 2-6. Risk Indicator for "Posture" and Neck/Shoulder Musculoskeletal Disorders
(Odds Ratios and Confidence Intervals)**



*Studies which met all four criteria
Note: Some studies indicate statistical significant association without a risk indicator. See Table 2-6.

Table 2-7. Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD Prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Anderson and Gaardboe 1993a	Cross-sectional	701 female sewing machine operators (SMO), compared to 781 females from the general population of the region and internal referent group of 89 females from the garment industry.	Outcome: Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for ≥30 days within the past year. Exposure: Job categorization based on "authors' experiences as occupational health physicians" and involved crude assessment of exposure level and exposure repetitiveness. Jobs involving high repetitiveness (several times/min) and low or high force, and jobs with medium repetitiveness (many times/hr) combined with high force were classified as high exposed jobs; jobs with medium repetitiveness and low force and jobs with more variation and high force were classified as medium exposed. Job titles such as teachers, self-employed, trained nurses, and the academic professions were "low exposed."	26.2%	General population: 9.9% Internal referent group: 6.7%	SMO compared to: (1) General population: OR = 3.2 (2) Internal referent group: OR = 4.9	2.3-4.5 2.0-12.8	Participation rate: 78.2%. Examiners blinded to control/subject status. Controlled for age, having children, not doing leisure exercise, smoking socioeconomic status. Logistic Model: Years as SMO: 0 to 7 years: 1.9 8 to 15 years: 3.8 >15 years: 5.0 Age ≥ 40 years: 1.5 Children (>0): 1.3 Exercise: 0.9 Socioeconomic status: 1.29
								Age-matched exposure groups and controls. Logistic regression limited to a combined neck/shoulder case definition. No difference in education, marital status, number of children. Poor correlation between degenerative X-ray neck changes and cervical syndrome. Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years. Chronic neck pain and palpitory findings: Sensitivity: 0.85; Specificity: 0.93.
								Current Exposure: 1.3 0.9-1.9

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments	
				Exposed workers	Referent group	RR, OR, or PRR	95% CI		
Andersen and Gaardboe 1993b	Cross-sectional	From a historical cohort of 424 sewing machine operators, 120 were randomly selected and 82 exposed workers were categorized by number of years of employment: 0-7 years, 8-15 years and greater than 15 years. These were compared to a referent group of 25 auxiliary nurses and home helpers. A total of 107 subjects participated.	Outcome: Measured by health interview and exam of the neck, shoulder and arm. Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for at least 30 days within the past year. Physical examination: Restricted movements in the cervical spine and either palpable tenderness in cervical segments or irradiating pain or tingling at maximum movements or positive foraminal test.	Referents: OR = 1 0 to 7 years: 2.3 8 to 15 years: 6.8 ≥ 15 years: 16.7	0 to 7 years: OR = 1 2.3 8 to 15 years: 1.6-28.5	0.5-11 4.1-67.5	Participation rate: 78.2%; logistic regression limited to a combined neck/shoulder case definition. Age-matched exposure groups and controls. Examiners blinded to control/subject status.	Controlled for age, having children, not doing leisure exercise, smoking, socioeconomic status.	Poor correlation between degenerative X-ray neck changes and cervical syndrome.
			Exposure: Exposure categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs: Involved high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs involved medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force.	Current high exposure: 1.6	0.7-3.6	Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years. Chronic neck pain vs. palpatory findings: Sensitivity: 0.85; Specificity: 0.93.			

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Baron et al. 1991	Cross-sectional	124 grocery checkers using laser scanners ($f = 119$, $m = 5$) compared to 157 grocery non-checkers ($f = 56$, $m = 101$); excluded 18 workers in meat, fish, and deli departments, workers under 18 and pregnant workers.	Outcome: Based on symptom questionnaire and physical exam. Case defined as having positive symptoms and a positive physical exam. Symptoms must have begun after employment at supermarket of employment and in current job; lasted one week or occurred once a month during the past year; no history of acute injury to part of body in question.	16%	5%	Odds of neck pain, checkers vs. non-checkers: OR = 2	0.6-6.7	Participation rate: 85% checkers; 55% non-checkers in field study. Following telephone survey 91% checkers and 85% non-checkers. Examiners blinded to worker's job and health status.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Bergqvist et al. 1995a	Cross-sectional	Office workers using VDTs, (n = 260), 198 females; symptomatic cases compared to non-cases.	Outcome: Neck discomfort—any discomfort over the last 12 months; intense neck discomfort – as above, if occurred in last 7 days and interfered with work.	Neck: 61.5% Female: 63% Male: 57%	Asymptomatic workers	Tension neck syndrome: Females no children: OR = 2.0	0.7-5.6	Participation rate: 92% of 353 office workers. Adjusted for age and gender.
			Outcome: Physiotherapist's diagnosis of: (1) tension neck syndrome (TNS); ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness; (2) cervical diagnoses—ache/pain in neck and arm; headache; decreased mobility due to cervical pain during isometric contraction; often root symptoms such as numbness or paresthesia.	TNS: 22% Female: 25% Male: 13%	Limited rest break: OR = 7.4	1.9-21.5	Factors included in analysis: Age, gender, smoking, children at home, negative affectivity, tiredness-related stress reaction, stomach-related stress reaction, use of spectacles, peer contacts, rest breaks, work task flexibility, overtime, static work position, non-use of lower arm support, hand in non-neutral posture, repeated movements with risk of tiredness, height differences keyboard/elbow, high visual angle to VDT, glare on VDT.	
			Exposure: Based on observation—static work posture, nonuse of lower arm support, hand in non-neutral position, insufficient leg space at table, repeated movements with risk of tiredness, specular glare present on VDT.	Too highly place keyboard: OR = 4.4	3.1-17.4	Found that "frequent overtime" protective for cervical diagnoses OR = 0.48 (0.23, 0.99).		
			Measured: Height difference of VDT keyboard-elbow, high visual angle to VDT.	Cervical Diagnoses: Age >40 OR = 2.7	1.0-7.2	Examiner and workplace investigators blinded to case and exposure status.		
				Spectacles: OR = 4.0	1.3-12.5	Stomach reactions: OR = 3.9	0.6-42.5	
				Static Posture: OR = 5.1	There are problems with interpreting results because of multiple comparisons and multiple models.	Spectral glare: OR = 1.9	0.9-4.2	
						Not all significant findings presented in paper.		
						Tiredness: 1.9	2.0-7.7	

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Bergqvist et al. 1995b	Cross-sectional	322 office workers; VDT users compared to non-VDT users. 52% interactive, 29% data entry, 19% non-VDT users.	Outcome: Neck discomfort—any discomfort over the last 12 months; intense neck/shoulder discomfort—as above, if occurred in last 7 days and interfered with work. Outcome: Physiotherapist's diagnosis of tension neck syndrome (TNS)—ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness.	Neck discomfort: 60% Intense neck discomfort: 7.4%	Current VDT work: OR = 1.4	0.8-2.4	Adjusted for age and gender.	Participation rate: 76%.
				Tension neck syndrome: OR = 1.0	Original 535 workers queried in 1981. Of those, 182 had left the workplace (quit, retired, etc.). Possible bias from "healthy worker effect."	0.5-1.9		
				TNS Diagnosis: <20 hr/week VDT: 1.2		6.4-3.7		
				>29 hr/week VDT: 0.7	0.3-1.5			Covariates considered: Children at home, smoking, negative affectivity, stomach-related stress reactions, tiredness-related stress reactions. Organizational factors considered: limited or excessive peer contacts, limited rest break opportunity, limited work task flexibility, frequent overtime.
				TNS diagnosis with bifocal or progressive glasses at VDT work and >20 hr/week VDT work duration: OR = 6.9	1.1-42.1			For cervical diagnoses: Excess OR suggested for combined occurrence of VDT work of >20 hr/week and specular glare on the VDT screen.

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Bernard et al. 1994	Cross-sectional	Of a total population of 3,000 workers in the editorial, circulation classified advertising and accounting departments, 1,050 were randomly selected for study and 973 participated. Those fulfilling case definition compared to those workers not fulfilling definition.	Outcome: Health data and psychosocial information were collected using a self-administered questionnaire. Definition: Presence of pain, numbness, tingling, aching, stiffness or burning in the neck occurring ≥ once a month or 7 days continuously within the past year, reported as moderately severe. The symptom must have begun during the current job. Workers with previous nonoccupational injuries to the relevant area were excluded.	26% (case) Cases with daily neck pain: 22%	— Number of hr spent on deadline/week (30 to 39 hr vs. 0 to 10 hr) OR = 1.7	OR = 2.1 1.4-2.4	Participation rate: 93%. Examiners blinded to case and exposure status.	Analysis controlled for confounders, age, gender, height, psychosocial factors, medical conditions.
			Exposure: Based on observation of work activity involving keyboard work, work pace, posture, during a typical day of a sample of 40 workers with and 40 workers without symptoms. Exposure to work organization and psychosocial factors based on questionnaire responses.	Work variance (continually changing work load; occasionally vs. often) OR = 1.7	Time spent on the telephone (4 to 6 hr vs. 0 to 2 hr); OR = 1.4	1.2-2.5 1.0-1.8	Psychosocial scales analyzed by splitting the responses into quartiles, then comparing the 75% response score to the 25% response score for deriving the ORs in each scale. In sub-analysis of jobs having comparable number of males and females. Only number of hr spent on deadline/week and perceived lack of importance for ergonomic issues by management were significant.	Perceived lack of importance for ergonomic issues by management: OR = 1.9 1.4-2.4

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ferguson 1976	Cross-sectional	418 telephonists interviewed	<p>Outcome: Symptoms by questionnaire. Neck ache categorized on 3-point discomfort scale: (1) very comfortable, (2) barely uncomfortable, and (3) uncomfortable, very uncomfortable.</p> <p>Exposure: Personal and social attributes and attitudes to aspects of the work and the equipment were obtained by questionnaire. Seven body dimensions were measured, and standing posture was categorized by observation against a grid according to predetermined criteria.</p>	<p>Telephonists: Uncomfortable or very uncomfortable neck ache = 26%</p>	<p>Chi sq = 11.01 (df = 2), $p < 0.005$</p>			<p>Participation rate: 95%.</p> <p>Although author states the following: "Discomfort, aching, and other symptoms are common, important but usually neglected problems in telephonists which could be ameliorated by ergonomic job and equipment," the results of his study did not support his conclusion.</p> <p>Neither discomfort nor aching was linked to any of the body postures observed.</p> <p>Height and weight were not related to discomfort or aching.</p> <p>Multiple correlations not helpful in identifying combinations of personal, equipment, environmental or other variables predictive of aching and discomfort.</p>

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence					Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	Participation rate:	
Hales and Fine 1989	Cross-sectional	Of 96 female workers employed in 7 high exposure jobs in poultry processing: 89 were compared to 23 of 25 female workers in low exposure jobs.	Outcome: Period prevalence—symptoms in last 12 months by questionnaire. Case defined as: Pain, aching, stiffness, numbness, tingling or burning in the neck and symptoms began after employment at the plant; were not due to a previous injury or trauma to the joint; lasted > 8 hr; and occurred 4 or more times in the past year.	Period prevalence: 21% Point prevalence: 12%	Period prevalence: 13% Point prevalence: 0%	Neck symptoms: RR = 1.64: OR indeterminate because of "0" cell	0.4-3.19 0.4-164	93%. Adjustment for age and duration of employment. Examiner blinded to case and exposure status. Exposure based on repetitive and forceful hand/wrist motions and not neck exposure assessment. 80% of workers involved in job rotation program. No information collected on non-work related risk factors.	

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Hales et al. 1994	Cross-sectional	Telecommunication workers ($n = 518$, $f = 416$, $m = 117$) in 3 offices, employed > 6 months.	Outcome: Self-administered questionnaire and standardized physical exam (PE). Case defined as: Pain, aching, stiffness, burning, numbness or tingling lasting > 1 week or > 12 times a year; no previous traumatic injury to neck; occurring after employment on current job within the last year and positive PE—moderate to worst pain experienced with tension neck or cervical root syndrome.	9%	—	Lack of decision making opportunities: OR = 4.2	2.1-8.6	Participation rate: 93%. Physician examiner blinded to worker case status.
		"Cases" fulfilling neck work-related MSD definition compared to non-cases.	Logistic analysis adjusted for demographics, work practices, work organization, individual factors; electronic performance monitoring; DAO keystrokes; Denver DAO keystrokes/day.	Use of bifocals: OR = 3.8	1.5-9.4			
			Lack of a productivity standard: OR = 3.5	1.5-8.3				ORs for psychosocial variables represent risk at scores one standard deviation above mean score compared to risk at scores one SD below mean.
			Exposure: Assessed by questionnaire and observation; number of keystrokes/day; no exposure questions were specifically aimed at the neck region.	Fear of being replaced by computers: OR = 3.0	1.5-6.1			Because of readjustments and changes of workstations during study period, measurements of VDT workstations considered unreliable and excluded from analyses.
			Physical workstation and postural measurements were taken but not analyzed in models.	High information processing demands: OR = 3.0	1.4-6.2			Number of hr spent in hobbies and recreational activities not significant.
				Job requiring a variety of tasks: OR = 2.9	1.5-5.8			Although keystrokes/day found not significant, data available was for workers typing an average of 8 words/min over 8-hr period.
				Increasing work procedure: OR = 2.4	1.1-5.5			97% of participants used VDT ≥ 6 hr so not enough variance to evaluate hr of typing.
								Over 70 variables analyzed in models may have multiple comparison problem.

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(Continued)

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR or PRR	95% CI	
Hunting et al. 1994	Cross-sectional	308 of 400 apprentice and journeymen, electricians from one labor union participated.	Outcome: Three-symptom definitions used; most restrictive includes neck symptoms occurring ≥once/month or lasting >1 week during past year, and no previous traumatic injury to site. Exposure: Questionnaire dealing with lifting activities, working overhead, working with hand tools.	16% 3% with medical visits, missed work, or light duty	— 1 to 3 years worked: OR = 1	— 4 to 5 years worked: OR = 1.3	— Participation rate: 75%. Stratified by most experienced vs. least experienced electrician, by age group, years worked, current work as an electrician.	98% of participants were male. Analysis of specific work factors (repetition, force, extreme posture, vibration, or combinations of risk factors) not analyzed in this paper which dealt with prevalence of symptoms among electricians.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Kamwendo et al. 1991	Cross-sectional	420 medical secretaries; compared those frequently having neck pain to those less frequently having pain.	Outcome: Questionnaire using 6 point scale ranging from "very often" to "almost never" and Nordic Questionnaire. Definition of neck MSD: Discomfort, ache, or pain during previous year; whether they had pain in last 7 days, whether pain prevented them from doing daily duties. 10 questions on psychosocial work environment included.	63% period prevalence.	—	OR for work with office machines 5 hr or more/day: 1.65	1.02-2.67	Participation rate: 96%. Neck symptoms associated with a "poorly experienced psychosocial work environment."

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR or PRR	95% CI	
Kiken et al. 1990	Cross-sectional	294 poultry processors plant #1 (n = 174) plant #2 (n = 120)	Outcome: Period prevalence—based on questionnaire. Case—pain, aching, stiffness, burning, numbness or tingling in the neck, began after employment at the plant; not due to previous accident or injury outside work; lasted > 8 hr and occurred 4 or more times in the past year.	Plant #1: (High exposure) Any symptoms: 34%	Plant #1: (Low exposure) Any symptoms: 16%	OR =	Participation rate: 98%. Analysis stratified by gender and age.	
			Point prevalence: Based on symptom and physical exam using standard diagnostic criteria. Case must fulfill symptom definition listed above.	Period prevalence: > 8 hr and occurred 4 or more times in the past year.	Point prevalence: prevalence: 9%	2.9	0.4-21.4	Higher exposure jobs (HE) were located in the receiving, evisceration, whole bird grading, cut up and deboning departments. Lower exposure jobs (LE) were located in the maintenance, sanitation, quality assurance and clerical departments.
			Exposure: Observation and walkthrough; jobs categorized as high exposure and low exposure based on observed force and repetition of hand maneuvers.	Plant #2: (High exposure) Any symptoms: 42%	Plant #2: (Low exposure) Any symptoms: 11%	OR =	30% of workers in job rotation program may influence associations.	Examiners blinded to case and exposure status.
				Period prevalence: 5%	Period prevalence: 3%	3.9	1.5-10.2	Annual turnover rate ~50% at plant 1 and 70% at plant 2; making survivor bias a strong possibility.
				Point prevalence: 1%	Point prevalence: 0%	1.8	0.2-15.2	——

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Knave et al. 1985	Cross-sectional	400 VDT operators from 4 industries using VDTs >4 hr/day; compared to 157 office employees without VDT work at the same industries.	Outcome: Questionnaire— symptom questionnaire based on frequency and intensity scores: negligible = 1, slight = 2, pronounced = 3. Exposure: Based on observation and self-assessment 'hrs of typing.' A special gaze direction instrument recorded time spent looking at VDT screen.	Results estimated from histogram: Histogram: Cases and referents matched on age and gender.	Results estimated from histogram: Histogram: Typing hr significantly related to neck symptoms.	Typing hr significantly related to neck symptoms.	—	Participation rate: Initially exposed 97%; referent 100%; Phase IV exposed 84% referents 84%.

Table 2-7 (Continued) Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Kukkonen et al. 1983	Cross-sectional/Intervention	104 female data entry workers. 60 data entry operators (noted as "study group") were grouped with 44 data entry operators who worked at another bank and were compared with 57 female workers in varying office tasks.	Outcome: Questionnaire—stiffness and pain in the neck and shoulder region, frequency of symptoms and localization. Physical exam (PE): A clinical functional examination performed by a physiotherapist.	Data entry groups: 47%	28%	2.3	1.1-4.6	Participation rate: Not reported. Examiners blinded to case status. No adjustment for confounders. Examiner blinded to case status. Average duration of employment 3.5 years. Intervention consisted of: Adjustment of desk, chairs, data processing equipment individually to suit each worker, who was instructed to carry out adjustments herself. Document holders were added. The study group was given a short course of basic training on pertinent aspects of ergonomics. Four lessons on relaxation was given by means of exercises. Physiotherapy was given to workers for whom the doctor prescribed – 17 from the study group and none from the first reference group had treatments.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR or PRR	95% CI	
Kuorinka and Koskinen 1979	Cross-sectional	93 scissor makers, (n = 90 females, 3 males) compared with 113 female department store shop assistants from Luopajarvi's 1979 study. Excluded those with seropositive rheumatic affections as well as cashiers.	Outcome: Symptoms and physical examination—two tender spots symptoms of neck stiffness and fatigue/weakness and/or palpable hardenings + muscle tenderness in neck movements. Physiotherapist examined workers, diagnoses were from predetermined criteria (Waris 1979). In problem cases orthopedic and psychiatric teams handled cases.	61%	28%	Scissor makers vs. referents: OR = 4.1	2.3-7.5	Participation rate: 81%. 99% female study group, no significant age difference. Used Waris (1979) criteria for examination which called for blinding of examiners, otherwise it was not mentioned. No association between: (1) age, (2) duration of employment, (3) weight/height ² and tension neck syndrome.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR or PRR	95% CI	
Linton 1991	Cross-sectional	22,180 employees undergoing screening examinations at their occupational health care service in Sweden. 85% of the Swedish workforce is covered by health care services.	Outcome: Cases defined from questionnaire responses as those persons reporting "yes" to having seen a health care professional for neck pain in the last year. Exposure: Based on questionnaire responses – questions asked regarding heavy lifting, monotonous or assembly line work, sitting, uncomfortable work postures (bending or twisting), vibration. Psychosocial work environment: Work content, workload, social support.	18% had seen health care professional for neck pain	—	Monotonous work and poor psychosocial environment: OR = 3.6	2.8-4.6	Participation rate: Authors had access to all workers' records; 85% of working population has occupational health care services. Analysis stratified for age, gender.
		Cases compared to "non-cases" defined by outcome. Groups selected <i>a priori</i> which would represent exposure as well as little or no exposure for psychosocial variables.	—	31% had experienced neck pain	—	Lifting and poor psychosocial environment: OR = 2.7	2.0-3.6	Lifestyle factors asked: Exercise, eating, smoking, alcohol consumption.
			—	Uncomfortable posture and poor psychosocial environment: OR = 3.5	—	On univariate analysis, heavy lifting, monotonous work, uncomfortable posture, and vibration had elevated ORs. Sitting did not.	2.7-4.5	On univariate analysis, eating regularly and smoking had elevated ORs. Alcohol and exercise did not.
			—	—	—	Authors caution direct comparison of ergonomic and psychosocial variable's ORs. The scales were not consistent for the different factors measured.	—	—

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Table 2–7 (Continued) Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Liss et al. 1995	Cross-sectional	1,066 of 2,142 dental hygienists from Ontario Canada Dental Hygienists Association compared to referent group, 154 of 305 dental assistants who do not scale teeth.	Outcome: Mailed survey, case definitions based on Nordic Questionnaire, percent reporting neck symptoms > 7 days in past 12 months. Exposure: Based on mailed survey and self-reported answers—length of practice, days/week worked, patients/day, patients with heavy calculus, percent of time trunk in rotated position relative to lower body, instruments used, hr of typing/week, type of practice.	43%	30%	1.7	1.1-2.6	Participation rate: 50% from both groups. Study population > 99% female. Had to modify their work or were unable to work at some point, (hygienists compared to dental assistants): OR = 2.4 No association with duration of employment. Not controlled for confounders. Very low response rate, confounders not considered, study has methodologic problems which influence interpretation of results.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR or PRR	95% CI	
Luopajarvi et al. 1979	Cross-sectional	Assembly line workers (n = 152 females) compared to shop assistants in a department store (n = 133 females). Cashiers excluded from comparison group.	Outcome: Tension neck syndrome (TNS): Neck stiffness and fatigue/weakness and two tender spots and/or palpable hardenings + muscle tenderness in neck movements. Exposure: Observation, video analysis, and interviews used to assess exposure to repetitive arm work, static muscle work affecting neck/shoulder area.	37%	28%	TNS: OR = 1.56	0.9-2.7	Participation rate: 84%. Workers excluded from participation for previous trauma, arthritis and other pathology. Had seen a doctor for neck symptoms: OR = 4.38

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Milnerad and Ekenwall 1990	Cross-sectional	99 dentists randomly selected from Stockholm dentist registry who practiced ≥ 10 years compared to 100 pharmacists selected from all pharmacists in Stockholm.	Outcome: Based on telephone questionnaire. Neck symptoms at any time before the interview ("lifetime prevalence"). Further analyzed according to Nordic questionnaire as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave.	Male: 45% Female: 63%	Male: 18% Female: 32%	2.6 2.0	1.2-5.0 1.3-3.1	Participation rate: 99%. Analysis stratified by gender. No difference in leisure time exposure, smoking, systemic disease, exposure to vibration. Symptoms increased with age in female dentists only.

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study design	Study population	Outcome and exposure	MSD prevalence				Comments
			Exposed workers	Referent group	RR, OR or PRR	95% CI	
Ohlsson 1995	Industrial Workers (n = 82 female) exposed to repetitive tasks with short cycles mostly for <30 sec, usually with a flexed neck and arms elevated and abducted intermittently; 68 former workers (mean employment time 21 years) who had left the factory during the seven years before the study; these workers were compared to 64 referents with no repetitive exposure at their current jobs.	Outcome: Pain in the last 7 days and physical exam (PE) diagnosing tension neck syndrome, cervical syndrome. Tension neck: Tightness of muscles, tender spots in the muscles. Cervical syndrome: Limited neck movement, radiating pain provoked by test movements, decreased sensibility in hands/fingers; muscle weakness of upper limb.	Tension neck: 40% Cervical syndrome: 1%	Tension neck: 13% Cervical syndrome: 0%	OR = 3.6	1.5-8.8	Participation rate: Current workers: (96%; past workers: 86%; referents: 100%). Controlled for age. No exposure information available to examiners, "not possible to completely blind the examiners." Questionnaire included individual factors, work/environment, symptoms, psychosocial scales. Muscle strength measured by (maximum voluntary capacity) at elevation, abduction, and outward rotation of both arms measured by dynamometer. Videotape analysis revealed considerable variation in posture even within groups performing similar assembling tasks. Logistic models replacing repetitive work with videotape variables found muscular tension tendency and neck flexion movements significantly associated with neck/shoulder diagnoses. Inverse relationship between duration of industrial work and MSDs, largest OR employed < 10 years. Assembly group has high OR (6.7) with regard to neck/shoulder MSD compared to referents. Significant association between

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR or PRR	95% CI	
Ohlsson et al. 1989	Cross-sectional	Electrical equipment and automobile assemblers ($N = 148$), 76 former female assembly workers who quit within 4 years compared to 60 randomly sampled females from general population.	Outcome: Determined by questionnaire—any neck pain, neck pain affecting work ability, and neck pain in the last 7 days and the last 12 months. Exposure: Based on job categorization and questionnaire—number of items completed/hr.	Pain in last 12 months: 39% Work inability in last 12 months: 13% Pain in last 7 days: 21%	Pain in last 12 months: 32% Work inability in last 12 months: 7% Pain in last 7 days: 17%	1.9 2.8 1.9	0.9-3.7 0.9-8.8 0.7-3.6	Participation rate: Not reported. For younger females, increase in pain occurred with increased duration of employment. OR increased with increasing work pace, except for very high paces, which there was a decrease. Logistic models checked for interaction and controlled for age. Study group consisted of females only. Significant association between symptoms and duration of employment much stronger for workers < 35 years old than workers > 35 years old.

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Onishi et al. 1976	Cross-sectional	The following were compared to 101 female office workers: Film rolling workers, 127 (females).	Outcome: Based on (1) symptoms of neck stiffness, dullness, pain, numbness; (2) pressure ($<1.5 \text{ kg/cm}^2$) measured by strain transducer at which subject felt pain; (3) physical exam: range of motion, tests, nerve compression tenderness.	Group I: 29%	Group II: 39%	Group III: 23%		Participation rate: Not reported. Body weight, weight skin fold thickness, muscle strength and grip strength obtained.
		Subjects categorized as: Group I: Without symptoms of cervico-brachial disorder. Group II: Subjective symptoms in the neck, shoulder, or upper limbs. Group III: Symptoms and clinical signs.	Exposure: Observation of job tasks, then job categorization. Film rollers wind 1 roll of 35 mm film every 2.5 to 5 sec over 7.5 hr/day. Loading of trapezius was examined in two workers during work activities by electromyography.	No difference between workers with tenderness threshold above 1.5 kg/cm^2 and those below with respect to age, height, weight, skin fold thickness, grip strength, upper arm abduction strength, back muscle strength.				Authors noted that continuous loading of the trapezius seems characteristic to repetitive operations where the upper limbs are used.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ryan and Bampton 1988	Cross-sectional	Data process operators (n = 143). Group with highest scores (n = 41) designated "cases," compared to lowest scores (n = 28).	Outcome: Symptoms (pain, ache, sore, hurts, numb, swollen, etc.) occurring ≥ 3 times/week with no physical exam signs or ≥ weekly with physical exam signs of muscle tenderness present; diagnosed "myalgia" as diffuse muscle pain and tenderness.	Shoulder: 44% symptom only	—	Not reported	—	Participation rate: 99%. Interviewers blinded to questionnaire responses.
			Exposure: Ergonomic assessment measuring angles and distances of each operator seated at his/her workstation. Wrist extension, ulnar deviation, elbow angle, shoulder abduction, and shoulder flexion were measured. Also measured: person and furniture fit, eye-copy and eye-keyboard fit, elbow-keyboard height difference, popliteal-chair height difference, and copy placement.	Neck: 43% symptoms only	Neck/ shoulder symptoms occurring ≥ 3 times weekly with no signs or weekly with signs:	44%	—	No adjustment for confounders; cases for analysis were those with either neck, shoulder, or lower arm scales having higher symptom scores compared to those with low scores.
				Cases had higher visual glare index, feeling there was insufficient time for rest breaks, more boredom, more work stress, and needed to push themselves > 3 times/week; lower peer cohesion, autonomy, clarity. Higher staff support and work pressure.				
				Significant differences in those trained in adjustment of their chairs.				
				No differences for height, weight, age, marital and parental status, handedness, time in current job, time spent keying or typing, whether this was their first job, length of training time.				
				Significant difference in smaller mean elbow angle and shoulder flexion of the left arm, and smaller eye-copy distance.				

(Continued)

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Sakakibara et al. 1987	Cross-sectional	Orchard workers ($n=48$, 20 males and 20 females).	Outcome: Shoulder pain described as the presence of stiffness and pain daily.	Estimated from histograms Pears:	Estimated from histograms Apples:	—	—	Participation rate: 77%. Stratified by gender.

Compared symptoms after completion of thinning of pears, bagging of pears and bagging of apples (covering fruit with paper bags while on the trees). Angles of flexion of the shoulder and extension of the neck on one subject were measured every 25 min during a whole day doing each task.

Internal comparison using same study population. Farmers worked approximately 8 hr/day for 10.6 to 13.6 days each year bagging or thinning pears and bagging apples.

Exposure: Observation of jobs.

Angles of flexion of the shoulder and extension of the neck on one subject were measured every 25 min during a whole day doing each task.

Estimated from histograms
Pears:
Rt. side: 2 0%
Lt. side: 9%
Rt. side: 9%
Lt. side: 9%

Estimated from histograms
Apples:
Rt. side: 2 0%
Lt. side: 9%
Rt. side: 9%
Lt. side: 9%

$p < 0.05$
 $p < 0.01$

The angle of forward flexion in the shoulder and that of extension in the neck was statistically significantly positively correlated ($r = 0.88$, $p \leq 0.01$). The proportion of workers with $> 90^\circ$ forward shoulder flexion was significantly higher for thinning out pears and bagging pears than for bagging apples.

The authors presumed that the symptoms of dizziness and tinnitus may be associated with the cochlear-vestibular symptoms of vertebral insufficiency due to continuous extension of the head.

Results presented in paper in histograms.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Sakakibara et al. 1995	Cross-sectional	Of 65 female Japanese farmers. 52 completed the questionnaire and physical exam in late June for bagging pears and late July for bagging apples.	Questionnaire: Stiffness and pain in neck region. Symptoms in past 12 months for ≥one day, or symptoms in past 12 months for ≥8 days.	Pear bagging	Apple bagging	Workers bagging pears with neck pain vs. apple bagging	Participation rate: 80%. Examiners not blinded to case status due to design of study.	
		Exam: Pain in motion of the neck joint such as flexion/extension, lateral bending, and rotation.	Neck pain = 40%	Neck pain = 25%	Workers bagging pears with pain in joint motion vs. apple bagging with pain in joint motion	Stiffness and pain during apple bagging may have been pain that was a residual of pear bagging operations.	0.99-2.35	
		Exposure: Observation of tasks and measurements of representative workers (only two workers measured) .	Angle of arm elevation during bagging was measured in one subject.	Neck pain in joint motion: 55.8%	Neck pain in joint motion: 36.5% controls	Number of fruit bagged/day was significantly more in pear bagging than in apple bagging.		
						Exposure measurements only obtained on 2 workers and generalized to all workers.		

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Schibye et al. 1995	Cohort	Follow-up of 303 sewing machine operators at nine factories representing different technology levels who completed questionnaire in 1985.	Outcome: Nordic Questionnaire—discomfort, ache, or pain in the neck during the previous year; whether they had neck pain in last 7 days, and whether pain prevented them from doing daily duties.	Neck symptoms in previous year for employees maintaining a piece-work	Developing neck symptom improvement in 1991 among operators compared to other employment group	OR = 0.85	0.29-2.4	Participation rate, 1985: 94%. Participation rate, 1991: 86%. All participants were female. 77 of 241 workers still operated a sewing machine in 1991. 82 workers had another job in 1991. Among those 35 years or below, 77% had left job; among those above 35 years, 57% left job.
In April 1991, 241 of 279 traced workers responded to same 1985 questionnaire.		Operators still working were compared to those who moved to other employment in 1991.	Exposure: Assessed by questions regarding type of machine operated, work organization, workplace design, units produced/day, payment system, and duration of employment as a sewing machine operator.	Neck symptoms in previous year for employees maintaining a piece-work groups of 100 to 125 units/day: 36%	Neck symptom improvement in other employment	OR = 3.3	1.4-7.7	20% reported musculoskeletal symptoms as the reason for leaving job. No significant changes in prevalences among those employed as sewing machine operators from 1985 to 1991; significant decrease in those who changed employment. As many as 50% of respondents reported a change in the response to positive or negative symptoms from 1985 to 1991. Operators always worked at the same machines showed significantly higher neck symptoms compared to those working at different machines Although the authors state that the analysis did not show the development of neck (or shoulder) symptoms among workers who had worked as a sewing machine operator to be significantly related to exposure, exposure time, or age, there was a significant drop-out rate of those above 35 years.



Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Veiersted and Westgaard 1994	Cohort	30 female chocolate manufacturing workers. 17 who contracted trapezius myalgia within 6 to 51 weeks compared to those workers without.	Outcome: Trapezius pain lasting > 2 weeks of a degree making it difficult to continue work. At least one tender or trigger point present. Prospective interviews every 10 weeks to detect symptoms of muscle pain. Daily "pain diaries" kept by subjects.	56% OR = 7.2	— Physical environment: OR = 0.9	Perceived strenuous postures: OR = 2.1-25.3	Participation rate: 55%. Drop-out rate may limit generalizability of results although drop-outs did not differ in exposure estimates and complaints.	Excluded subjects with: (1) no similar occupation during last 5 years; (2) known musculoskeletal disorder predisposing for myalgia; (3) neck or shoulder pain sufficient to initiate medical visit, (4) if employed < 26 weeks.
			Exposure: Static muscle tension during work was between 1 and 2% of maximal voluntary activity of the trapezius muscles recorded by electromyographic measurements of trapezius muscle in earlier study. Interviews conducted prospectively every 10 weeks concerning exposure at work for 1 year.	OR = 3.3 OR = 6.7	Perceived strenuous previous work: OR = 3.3	0.8-14.2 1.6-28.5	Several anthropometric, non-work-related, general health, personality, psychosocial, and previous employment variables included in initial interview and follow-ups.	Subjects on a fixed-wage system. Work was mainly machine-paced. Nine of 17 with trapezius myalgia had sick leave after medical consultation.
							No difference in general health status, anthropometric measures. None of the models showed any effect of the "physical environment." Parameters which included exposure to draft, vibration (floor or machine), or noise.	Observation time was considerably shorter for workers who contracted neck pain compared to status used in analysis. Non-patients had more opportunities to report a positive answer.
							The perceived strenuous postures were not reflected in any of the conventional EMG parameters (static, median or peak loads).	

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Viikari-Juntura et al. 1994	Cohort longitudinal; 2 questionnaires 3 years apart	688 machine operators and 553 carpenters compared to 591 office workers. All male.	Outcome: Neck trouble, categorized on 5 point scale ("not any" to "daily"). Exposure: Based on job category. Machine operators - static work with whole body vibration, carpenters - dynamic physical work, office workers - sedentary work. For initial evaluation, observation of work sites were performed.	12 month prevalence for severe neck pain to moderate: OR = 1.6	Carpenters vs. office workers: No neck pain to severe neck pain for 1984/1987	1.0-2.5	Participation rate: 81% machine operators; 79% carpenters; 89% office workers.	Adjusted for occupation, smoking, and physical exercise, age, duration or current occupation.
				No neck pain to severe: OR = 1.6	No neck pain to severe: OR = 1.6	0.8-3.0	2% had retired.	In multivariate analysis: "occupation" was only significant predictor in change from no neck trouble to moderate neck trouble.
				Persistently severe: OR = 3.0	Machine operators vs. office workers: 9/12%	1.4-6.4		Twisting or bending trunk not a significant predictor of neck pain.
				No neck pain to moderate: OR = 1.8	Machine operators vs. office workers:	2.0-9.0	In multivariate analysis: occupation, age, and current smoking were significant predictors in change from no neck trouble to severe neck trouble.	
				No neck pain to severe: OR = 3.9	No neck pain to severe: OR = 4.2	2.3-6.9	Interaction between age and occupation not significant.	
				Persistently severe: OR = 4.2	Job satisfaction not associated with neck trouble and other predictors.	2.9-2.6		

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Welch et al. 1995	Cross-sectional	39 of 47 sheet metal workers attending a screening for occupational lung disease. Cases compared to those without symptoms.	Outcome: Symptom survey; pain, aching, stiffness, burning, numbness or tingling in neck ≥ once/month, or lasting > one week, no history of previous traumatic injury. Symptoms began after working as a sheet metal worker and prior to retirement.	21%	Comparison group with no symptoms	Percent time hanging duct: OR = 7.5	0.8-68	Participation rate: 83%. Smoking cigarettes, average number of years working not found to be significantly different between symptomatic and asymptomatic; other confounders (age, gender) not mentioned. Average length of employment in trade: 33 years.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR or PRR	95% CI	
Wells et al. 1983	Cross-sectional	196 male letter carriers compared to 203 male meter readers and postal clerks.	Outcome: Telephone interview case status based on current pain; frequency, severity, interference with work, etc.; score of 20 required to be a case—more points given to neck and shoulder problems than interfered with routine daily activities. Exposure: Based on job category; based on self-reported information on weight carried, previous work involving lifting and work-related injuries.	All letter carriers: 12% Letter carriers with no weight increase: 12%	Postal clerks: 5% Letter carriers: 7%	All letter carriers vs. clerks and readers: OR = 2.57 Letter carriers with increased weight vs. clerks: OR = 2.63	1.13-6.2 0.9-8.8	Participation rate: 99% among letter carriers, 92% meter readers, 97% postal clerks. No significant difference in schooling and marital status. Comparison group (gas meter readers) used because of similar "walking rate" without carrying weight compared to letter carriers. Postal clerks neither walk nor carry weight. More weight given to scoring neck and shoulder. Outcome influenced results when ranking of body MSDs though would not influence group comparisons. Adjusted for age, number of years on the job, Quietelot ratio and previous work experience. Study limited to males.

Table 2-7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Yu et al. 1996	Cross-sectional	151 VDT users from an international bank in Hong Kong; of these 90 were data entry, data processing, computer programmers; 61 infrequent users of VDTs.	Outcome: Questionnaire survey used to collect information on discomfort or ache during work after starting the current job. Exposure: Questionnaire survey on "undesirable postures", including frequent bending of the back and inclining the neck forwards.	31.4%	Frequent users of VDTs vs. infrequent users: $p = 0.0025$			Participation rate: 80%. Ages ranged from 18 to 41 years, 74% between 21 to 30 years. Analysis controlled for "age and gender, and other covariates."
				Logistic model for neck pain inclining neck at work: $OR = 784.4$	33.2-18,630			Queried about personal particulars, job nature and characteristics, working posture, general health conditions.
				Fixed keyboard height: $OR = 90.1$	7.6-1056			Males with significantly longer mean VDT working experience compared to females (5 vs. 2.7 years).
				Frequent VDT use: $OR = 28.9$	2.8-291.8			Non-workplace factors not examined.
				Female gender: $OR = 1.6$	0.35-6.8			
				Age (years): $OR = 1.2$	1.02-1.5			

Table 2–8. Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Åarase 1994	Prospective	15 female assembly workers making telephone exchanges.	Outcome: Assembly Workers: musculoskeletal sick leave/man-labor years; pre- and post-intervention. 1967 to 1974:	Number of musculoskeletal diagnoses: pre-intervention, 52 (30.6%)	Duration of sick-leave/man-labor year (days)			Participation rate: Not reported. Study designed to evaluate if there is a relationship between trapezius load and incidence of MSD.
		27 female VDT users.	Data Entry and VDT Users: Survey: Pain intensity for the neck and shoulder region according to Nordic questionnaire.	Number of musculoskeletal diagnoses post-intervention, 22.9	Median sick days pre-intervention: 22.9	4.4-50.8		Other intervening variables that may have reduced symptoms or sick leave were not discussed.
		25 female data entry operators.						
		29 male VDT users.	Exposure: Load on trapezius as measured by EMG. Quantification of the muscle load done by ranking the interval estimate (0.1 s) to produce an amplitude probability distribution function. Both total duration and number of periods/min. when muscle activity was below 1% MVC were calculated.	1975 to 1982: 35 (14.3%)	Median sick days post-intervention: 1.8	0-34.4		Mean static trapezius load in assemblers was reduced from 4.3% MVC to 1.4% (post-intervention); mean static trapezius load in VDT users reduced from 2.7% MVC to 1.6% MVC (post-intervention).
					Shoulder Pain Intensity	3.4	2.3-4.4	The mean intensity and duration of neck pain showed no significant reduction after intervention in the data dialogue females.
						2.2	1.3-3.3	
								Intervention: Replacing workstands with fixed heights to workplaces easily adjustable for both sitting and standing. Hand tools were counter-balanced and adjustable arm rests introduced. For VDT operators, tables and chairs adjusted to give more relaxed position of the shoulders, operators given more work surface for keyboard and mouse, and distances between operators and screen/documents adjusted.

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Andersen and Gaardboe 1993a	Cross-sectional	701 female sewing machine operators, compared to 781 females from the general population of the region and internal referent group of 89 females from the garment industry.	Outcome: Case of chronic neck pain was defined as continuous pain lasting for a month or more after beginning work and pain for ≥ 30 days within the past year. Exposure: Categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs were those involving high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs were those involving medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force.	34.2%	General population: 12.9% Internal referent group: 10.1%	Sewing machine operators compared to: (1) General population: OR = 3.5 (2) Internal referent group: OR = 4.6	2.6-4.7 2.2-10.2	Participation rate: 78.2%. Examiners blinded to case status. Respondents excluded if had previous trauma to neck, shoulder, or arms or had inflammatory disease at time of response. Odds ratios adjusted for age, having children, not doing exercise, socioeconomic status, smoking, and current neck/shoulder exposure.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Anderson and Gårdbo 1993b	Cross-sectional	From a historical cohort of 424 sewing machine operators, 82 were randomly selected and categorized by number of years of employment: 0 to 7 years, 8 to 15 years and greater than 15 years. These were compared to a referent group composed of 21, 25 and 36 operators from each group and 25 of 55 auxiliary nurses and home helpers who participated in the study.	Outcome: Measured by health interview and exam of the neck, shoulder and arm. Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for ≥ 30 days within the past year. Physical examination: Restricted movements in the cervical spine and either palpatory tenderness compared to a referent in cervical segments or irradiating pain or tingling at maximum movements or positive forearm test.	50.9%	46.2%	Referrals: OR = 1	Participation rate: 78.2%.	Logistic regression limited to a combined neck/shoulder case definition.
			Exposure: Exposure categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs: Involved high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs involved medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force.	Tension neck syndrome: 40%	0 to 7 years: OR = 2.3	0.5-1.1		
				Cervical Syndrome: 20%	8 to 15 years: OR = 6.8	1.6-28.5		Age-matched exposure groups and controls.
				>15 years: OR = 16.7	4.1-67.5	4.1-67.5		Examiners blinded to control/subject status.
				Age ≥ 40 years: OR = 1.9	0.9-4.1	0.9-4.1		Controlled for age, having children, not doing leisure exercise, smoking, socioeconomic status.
				Children > 0 years: OR = 0.5	0.1-1.7	0.1-1.7		Poor correlation between degenerative X-ray neck changes and cervical syndrome.
				Exercise: OR = 1.4	0.6-2.96	0.6-2.96		Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years.
				Smoking: OR = 1.5	0.7-3.3	0.7-3.3		Chronic neck pain vs. palpatory findings: Sensitivity: 0.85; Specificity: 0.93.
				Current high exposure: OR = 1.6	0.7-3.6	0.7-3.6		

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence			Comments
				Exposed workers	Referent group	RR, OR, or PRR 95% CI	
Bergqvist et al. 1995a	Cross-sectional	260 office workers using VDTs, 198 females; symptomatic cases compared to non-cases.	Outcome: Neck/shoulder discomfort: Any discomfort over the last 12 months; intense neck discomfort: As above, if occurred in last 7 days and interfered with work. Physiotherapist's diagnosis of (1) Tension neck syndrome: Ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness; (2) Cervical diagnoses: Ache/pain in neck and arm; headache; decreased mobility due to cervical pain during isometric contraction; often root symptoms such as numbness or parathesias.	Neck/shoulder: 61.5% Female: 63%	Intensive neck/shoulder discomfort: stressful stomach reactions: OR = 5.4	RR, OR, or PRR 95% CI 1.6-17.6	Participation rate: 92% of 353 office workers, of which 260 were VDT users. Adjusted for age and gender. Examiner and workplace investigators blinded to case and exposure status.

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(Continued)

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence			Comments
				Exposed workers	Referent group	RR, OR, or PRR 95% CI	
Bergqvist et al. 1995b	Cross-sectional	322 office workers from 7 Stockholm companies; VDT users compared to non-VDT users	Outcome: Neck/shoulder discomfort: Any discomfort over the last 12 months; intense neck/shoulder discomfort: As above, if occurred in last 7 days and interfered with work.	Neck/shoulder discomfort: Current VDT work vs. no VDT work: OR = 1.4	Neck/shoulder discomfort: Current VDT work vs. no VDT work: OR = 1.4	0.8-2.4	Participation rate: 92% questionnaire; 91% physiotherapy exam; 82% workplace exam.
			Physiotherapist's diagnosis of tension neck syndrome; Ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness.	For accumulated VDT work > 5 PY ² : OR = 1.3	Intense neck/shoulder discomfort: Current VDT work vs. no VDT work: OR = 0.5	0.7-2.5	Examiner and workplace investigators blinded to case and exposure status.
			Exposure: Video display terminal use: Based on self-reporting of VDT use. VDT users categorized into data entry or interactive VDT users.	For accumulated VDT work > 5 PY ² : OR = 0.8	0.2-1.8	0.3-2.5	For cervical diagnoses: Excess OR suggested for combined occurrence of VDT work of > 20 hr/wk and specular glare on the VDT screen.
			Ergonomic Factors: Same as Bergqvist 1995a.				Covariates considered: Children at home, smoking, negative affectivity, stomach-related stress reactions, tiredness-related stress reactions; organizational factors considered limited or excessive peer contacts, limited rest break opportunity, limited work task flexibility, frequent overtime.

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Bjelle et al. 1981	Case-control	13 workers of industrial plant consecutively seen at health clinic with acute, nontraumatic neck/shoulder pain not due to causative disease or malformation compared to 26 controls. Matched on age, gender, and place of work.	Outcome: Physician diagnosed neck/shoulder pain. Exposure: Anthropometric and isometric muscle strength were tested with strain gauge instruments. Patients asked to perform their maximal efforts. Measurements made for the following contractions: Shoulder elevation at the acromion, abduction and forward flexion of the shoulder joints at neutral position, and semi-pronated.	6 with tendinitis	Controls without tendinitis	Cases had significantly longer duration and higher frequency of abduction or forward flexion than controls, 2.5/min. ($p < 0.001$).	Participation rate: Not reported. Investigators completed the video analyses blinded to case status. Anthropometric data, age no difference between cases and controls.	Median number of sick-leave days significantly different between cases and controls ($p < 0.01$).

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Bläder et al. 1991	Cross-sectional	Of 224 sewing machine operators from 4 plants, 199 completed a symptom survey. Of 155 who reported shoulder or neck pain in the past 12 months, 131 were examined.	Outcome: Survey: Shoulder or neck pain in past 12 months. Exam: Tenderness on palpation, range of motion, pain during motion or isometric muscle contraction, active and passive range of motion was measured by use of a goniometer. Diagnoses were not made during the examinations, but test forms were later analyzed by criteria from Waris 1979.	Muscle tenderness: Acromioclavicular joint: 15% Biceps tendon: 35% Decreased ROM: 30%	— Age Nationality	$p < 0.05$ $p < 0.05$	Participation rate: 89% for questionnaire, 87% for physical exam. Only those with symptoms given physical exam. Physicians and physiotherapist not blinded to symptom status.	

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ekberg et al., 1994	Case-control	Study population were aged 18 to 59 years, had to have yearly incomes of SEK 45,000 and not been on sick leave for more than 2 months in past 6 months, not employed in large rubber industry in area.	Outcome: Self-administered questionnaire; a modified version of the Nordic questionnaire asking about musculoskeletal symptoms in the past 6 months. Questionnaire included background factors, age, gender, ethnic background, family situation, smoking habits, and exercise. "Cases" had consulted a community physician for musculoskeletal disorders of the neck, shoulder, arm, or upper thorax during the study period from semi-rural community in southern Sweden. Cases had to have been ill immediately prior to physician visit and have been on sick leave at most less than 4 weeks. No trauma, infectious cause, accident, malignancy, rheumatic disease, abuse, or pregnancy.	—	—	Female gender: OR = 15.5	90% CI used in this paper 3.4,71	Participation Rate: 73%. Logistic analysis adjusted for age, gender, smoking, having preschool children.

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ekberg et al. 1995	Cross-sectional	637 of 900 residents between the ages of 18 to 59 years, with an average yearly income of $\geq \$8000$ U.S. dollars.	<p>Outcome: Based on modified Nordic questionnaire; case defined as the presence of symptoms during the past 6 months.</p> <p>Exposure: 20 questionnaire items on physical work conditions which were factor analyzed. Self-reported perception of physical work environment factors considered:</p> <ul style="list-style-type: none"> Uncomfortable sitting or standing position; physically demanding work; light lifting; repetitive movements demanding precision; work with lifted arms, monotonous work position. 	<p>Symptoms neck: Male: 33% Female: 53%</p> <p>Shoulder: Male: 35% Female: 40%</p>	<p>Gender: OR = 1.3</p> <p>Immigrant Status: OR = 1.3</p>	<p>1.1-1.5</p> <p>1.0-1.6</p>	<p>Participation rate: 73%.</p> <p>Symptom responses in neck and shoulder correlated ($r = 0.56$) and collapsed into one variable for the analyses.</p> <p>Age, smoking, exercise habits, family situation with preschool children not significantly associated with symptoms.</p>	
								<p>Social work climate, demands on attention, work planning, job security and job constraints not significantly associated with symptoms.</p> <p>Low work content lack of stimulation and variation: OR = 1.3</p> <p>Work role ambiguity: OR = 1.2</p>

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Herberts et al. 1981	Cross-sectional	131 male shipyard welders with > 5 years of work experience compared to 57 male office clerks. All workers participated in the shipyard's medical program which offered medical exams every 5 years.	Outcome: Positive answers to questions about repeated occurrences of shoulder pain during work; shoulder stiffness that affected work and weakness in shoulder that affected work or weakness or numbness in arm or hand and participation in a follow up exam. Exposure: Estimation of workload with assessment of the workplace into 3 groups very high, high or low. Static loading while holding tools; awkward postures; shoulder level or overhead work.	Supraspinatus tendinitis (ST) results of 23 welders called back for clinical follow-up exams: 16 welders had ST. Shoulder pain reports from the questionnaire: 27%	Shoulder Pain Prevalence from questionnaire, welders vs. office workers: 1.8% PFR = 15.2 (adjusted OR)	PRR of shoulder pain results from questionnaire, welders vs. office workers: 2.1-108 (adjusted OR)	1.14-332	Participation rate: Not reported. Incidence estimated to be 15% to 20% a year. Welders with and without tendinitis were age-matched. We question the methods used to approximate the prevalence of shoulder tendinitis. Authors stated that they took into account the missing data in the investigation and assumed that the drop-out group did not deviate from the examined group, so they used "proportional" to obtain the number of cases of ST cases in the welders for calculations of prevalence ate ratios; number of ST cases increased from 16 to 24.

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Turnover of shipyard welders mentioned at 33%.

Shoulder tendinitis was not found to be associated with increasing age.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study design	Study population	Outcome and exposure	MSD prevalence				Comments	
			Exposed workers	Referent group	RR, OR, or PRR	95% CI		
Holmström et al. 1992	Cross-sectional	Of 2500 construction workers randomly selected from 4,159 active members of trade union registry of the south of Sweden, 1,773 (71%) participated. This group was represented by all construction trades except painters, electricians and plasterers. All participants must have worked in the past 6 months, including short periods of sick leave or unemployment.	Outcome: Self-reported history of musculoskeletal problems was obtained through a mail survey. Case of "neck and shoulder pain" defined as: Pain, ache, discomfort from the neck/shoulder are experienced sometimes often or very often during the past 12 months.	Hands above shoulder < 1 hr/day 1 to 4 hr/day > 4 hr/day	—	1.1 1.5	0.8-1.5 1.2-1.9	Participation rate: 71%. Neck/shoulder pain related to increasing age, smoking, weight inactivity during free time, height under 185 cm.
				Hands at waist < 1 hr/day / 1 to 4 hr/day > 4 hr/day	2.0	1.4-2.7	Controlled for age, physical factors. Dose-response relationship for working with hands above shoulder level.	
				Stooping < 1 hr/day 1 to 4 hr/day > 4 hr/day	1.0 1.1	0.7-1.3 0.9-1.3	Stress index showed a dose-response. Stress questions pertained to rushing, job pressure, and inability to relax.	
				Kneeling < 1 hr/day 1 to 4 hr/day > 4 hr/day	1.2	0.8-1.6	Psychosocial factors strongly associated with neck and/or shoulder trouble and neck and shoulder pain when age and physical factors kept constant in logistic models for psychosocial pre-rate ratio, "high" level compared with "low" level for considerable neck pain; the following psychosocial scales were significant: Qualitative demands 1.4 (1.0-2.0) Quantitative demands 3.0 (2.1-4.0) Solitary work 1.5 (1.2-1.8) Anxiety (health) 3.2 (2.5-4.0) Psychosomatic 5.0 (3.6-6.9) Psychological 4.7 (3.6-6.0) Stress 3.4 (2.6-4.2)	
				Sitting < 1 hr/day 1 to 4 hr/day > 4 hr/day	1.5	1.1-2.1	The following were not significant: Discretion, support, understimulation, anxiety (work), job satisfaction, quality of life.	
				Roofers Plumbers Floor Machines/ Tools.	0.6 1.6 0.9-2.7	0.3-1.0 — —	— — —	
					0.7	0.4-1.2	—	

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Hünting et al. 1981	Cross-sectional	VDT users: 53 data entry; 109 conversational VDT users; 78 typists; compared to 55 "traditional office workers" not using VDTs or typewriters.	Outcome: Questionnaire: Symptoms of pain, stiffness fatigue, cramps, numbness, tremor scaled as: Daily, occasionally, seldom, never; Medical Exam: Included an anamnesis and palpation of painful pressure points and tendons and tendon insertion points in the shoulders, arms, and hands.	Medical findings in shoulder and neck.	Medical findings in shoulder and neck:	Medical findings	Participation rate: Not reported. No adjustment for age and gender. Blinding of examiners not mentioned in paper.	Medical findings in neck and shoulder significant in data entry workers for head inclination greater than 56° vs. < 56°. Not significant in conversational terminal workers or typewriters.
			Exposure: (1) Questionnaire, (2) Observation and measurements of work-station, and (3) Body posture measured using method described by Hünting et al. 1980b.	Conversational VDT users: 28% Traditional office workers: 11%	Traditional office workers:	OR = 1.35	0.6-3.1	The lower the table and keyboard heights, the more frequently pains in the shoulder, neck, and arms. No document holders used. Authors concluded the higher the table, the higher the documents, the better the posture of the head and trunk.
			Data Entry terminal VDT users: 38%	Typewriter vs. trad. office workers: OR = 3.18	Typewriter vs. trad. office workers: OR = 3.18	1.3-2.6	Increased neck/shoulder findings occurred with increased turning of the head or head inclination.	Job satisfaction, relationship with colleagues, superiors, decision making abilities, use of skills not significantly different among groups.
			Data entry terminal users vs. trad. Office workers: OR = 9.9	3.7-26.9				

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Jonsson et al. 1988	Cohort	Electronics Workers (n = 69 female) out of initial 96 workers.	<p>Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of 2 or greater than on a 4 point scale; "severe" symptom score = 4.</p> <p>Carried out at outset of study: MVC of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion.</p> <p>Exposure: Computerized via two video recordings (rear and side), real time; obtained frequency and duration of working postures and movements, neck flexion greater than 20°.</p>	<p>Severe neck disorders: After 1 year: 24% restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of 2 or greater than on a 4 point scale; "severe" symptom score = 4.</p> <p>Carried out at outset of study: MVC of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion.</p> <p>Exposure: Computerized via two video recordings (rear and side), real time; obtained frequency and duration of working postures and movements, neck flexion greater than 20°.</p>	<p>Severe neck disorders: 11% initially from 2nd to 3rd examination:</p> <p>Palpation tenderness, neck/ shoulder angle: OR = 1.6</p> <p>Shoulder elevated % of work-cycle: OR = 1.04</p>	<p>Predictors of change of health status from 2nd to 3rd examination:</p> <p>Predictors of improvement were reallocation, physical activity in spare time, and high productivity (after 2 years).</p> <p>Predictors of remaining healthy were work without elevating the shoulders and satisfaction with work tasks.</p>	<p>Predictors of deterioration were previously physically heavy jobs, high productivity (after 1 year), and previous sick leave.</p> <p>Predictors of improvement were reallocation, physical activity in spare time, and high productivity (after 2 years).</p> <p>Predictors of remaining healthy were work without elevating the shoulders and satisfaction with work tasks.</p>	<p>Participation rate: 72%.</p> <p>Non-sitting, no inspection of small details on printed circuit boards, standing and walking, occasionally sitting, caretaking work, surveillance of machinery, assembling of bigger and heavier equipment.</p>

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Kilbom et al. 1986, 1987	Cross-sectional	106 of 138 female assemblers in two electronic manufacturing companies agreed to participate; 10 excluded because of symptoms in past 12 months. 96 underwent medical, physiological, and ergonomic evaluation.	Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, relation to work or other physical activities. Analyzed if score on any symptom of 2 or > on a 4 point scale; "severe" symptom score = 4.	MSD symptoms in the neck/shoulder using a 4 point severity scale: None: 78% Slight: 8%	—	Logistic Regression model (all variables significant at the $p < 0.05$ level)	—	Participation rate: 77%. The authors followed up on the non-participants and found no significant differences from participants. No relation between maximal static strength and symptoms. Examiner blinded to case status.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Linton and Kamwendo 1989	Cross-sectional	420 of 438 medical secretaries and office personnel at a Swedish hospital.	Outcome: 3-point scale collapsed from 6-point frequency scale ranging from "almost never" to "almost always" having neck or shoulder discomfort; and Nordic Musculoskeletal Pain Questionnaire.	Shoulder pain frequency	—	Those frequently having neck and shoulder pain vs. those less frequently having pain:		Participation rate: 96%. 75% sat > 5 hr/day. 43% worked with office machines each day.
		Those reporting frequently having neck and shoulder pain (1 to 3) compared to those less frequently having pain (4 to 6) points).	Exposure: 10-question standardized form on the psychological work environment with 1 to 4 categorical scales. Overall score and indexes on work content, psychologic work demand and social support at work.	Sometimes a wk: 4.8%	Poor Work Content: OR = 2.5	1.3-4.9		Psychosocial scale scored: 10 to 20 as good environment. 20 to 40 as poor environment.
			Duties included daily use of typewriter, VDT, plus mail telephone and appointment duties.	Sometimes a wk: 4.8% Overall score and indexes on work content, psychologic work demand and social support at work. Never: 32.1%	Lack of Social Support: OR = 1.6	0.9-2.8		Authors noted that: (1) Secretaries exposed to high work demands periodically, (2) They also felt helpless to change the work environment, and that (3) Internal conflict within departments may have affected responses.

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Maeda 1982	Cross-sectional	119 accounting machine operators aged 17 to 29 years in a post-check office.	Outcome: Based on questionnaire responses of pain and stiffness in the right and left sides of the neck and shoulder based on frequency of "almost every day, occasionally, and never or seldom" during the previous several wk. Scores were factor analyzed. Exposure: Anthropometric parameters relevant to the job tasks were measured on 51 operators who showed large or small factor scores.		Partial correlation coefficient between head neck tilt and factor score 1 to 5, controlling for other angles "A and C", age, and length of service 0.25			Participation rate: Not reported. Examiners blinded to case status: Not reported. Constrained tilted head posture was associated with neck/shoulder stiffness.

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Milnerad and Ekenvall 1990	Cross-sectional	99 dentists randomly selected from Stockholm dentist registry who practiced ≥ 10 years compared to 100 pharmacists selected from all pharmacists in Stockholm.	Outcome: Based on telephone questionnaire: Neck symptoms at any time before the interview ("lifetime prevalence"). Further analyzed according to Nordic questionnaire as to duration during last 12 months and during last 7 days, effect on work performance, leisure activities, and sick leave.	Neck and Shoulder: Males: 36% Females: 67%	15% 28%	2.4 2.4	1.0-5.4 1.5-3.7	Participation rate: 99%. Analysis stratified by gender. No difference in leisure time, smoking, systemic disease, exposure to vibration.
			Exposure: Questionnaire included: (1) Abduction of arm particularly in sit-down dentistry, (2) Work hr/day, (3) Static postures.	All dentists: Neck and Shoulder: 36% Neck and Shoulder and Arm: 16%	17% 3%	2.1 5.4	1.3-3.0 1.6-17.9	Symptoms increased with age in female dentists only. Duration of employment highly correlated with age ($r = 0.84, 0.89$). No relation between symptoms and duration of employment. Equal problems dominant and non-dominant sides.

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ohara et al. 1976	Cross-sectional and prospective	For cross-sectional study: 399 cash register operators compared with 99 office machine operators and 410 other workers (clerks and saleswomen). All female.	Outcome: Assessed by standard health inventory and medical examination (used clinical classification according to the committee on cervicobrachial disorders of the Japan Association of Industrial Health, in Table 3 in the paper). Periodic physical exam performed twice a year from 1973. Primary exams performed on 371 operators. 130 (35%) received detailed exams.	Cash register operators	Office machine operators and other workers (clerks and saleswomen)	Office machine operators and other workers (clerks and saleswomen)	Participation rate: for prospective study = 100%.	Interventions did not reduce complaints in the shoulder region, but did improve symptoms in the arms, hands, fingers, low back, and legs. The lack of improvement in the shoulder region was stated to be due to the use of the same narrow check stands, unsuitable counter height, and necessity of continuous lifting of the upper limbs.
			Exposure: To repetitive movements relocating merchandise across counter and upper limbs.	NR			Participation rate: for cross-sectional study, unable to calculate from data presented.	Unknown whether examiners blinded to case status.
			86 operators, newly hired after interventions, also had interventions, also had evaluations after 10 months of working.				Only 14.5% with > 3 years employment at worksite.	
			Interventions: (1) a 2-operator system, 1 working the register, one packing articles, changing roles every hr; (2) continuous operating time < 60 min; max. working hrs/day 4.5 hrs.; (3) 15-min. resting period every hr; (4) electronic cash registers with light touch keyboard substituted for half of previously used				Narrow work space and counter height not adjusted for height of worker. mechanical cash registers.	

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study design	Study population	Outcome and exposure	MSD prevalence				Comments
			Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ohlsson et al. 1995	Cross-sectional	Industrial Workers (n = 82 female) exposed to repetitive tasks with short cycles mostly far < 30 sec., usually with a flexed neck and arms elevated and abducted intermittently; 68 former workers (mean employment time 21 years) who had left the factory during the 7 years before the study; these workers were compared to 64 referents with no repetitive exposure at their current jobs (female residents of a nearby town currently employed as customer service, ordering and price marking in supermarkets, as office workers (no constant computer work) or as kitchen workers.	Outcome: Pain in the last 7 days and PE diagnosing tension neck syndrome, cervical syndrome. Tension neck: Tightness of muscles, tender spots in the muscles. Cervical syndrome: Limited neck movement, radiating pain provoked by test movements, decreased sensibility in hands/fingers; muscle weakness of upper limb. Muscle strength measured by MVC at elevation, abduction, and outward rotation of both arms measured by dynamometer. Exposure: Videotaping and observation. Analysis of postures, flexion of neck (critical angles 15° and 30°). 74 workers videotaped > 10 min. from back and sides. Average counts of two independent readers for frequencies, duration, and critical angles of movement used.	Industrial workers: 50% Referents: 16%	All neck/shoulder clinical diagnoses (industrial workers compared to referents): OR = 2.7	1.2-6.3	Participation rate: Current workers: 96% Past workers: 86%; Referents: 100%. No exposure information available to examiners, "not possible to completely blind the examiners." Questionnaire included individual factors, work/environment, symptoms, psychosocial scales. Videotape analysis revealed considerable variation in posture even within groups performing similar assembling tasks.

Logistic Model:
Repetitive work vs. none: OR = 4.6
Age (57 vs. 37): OR = 1.9
1.0-3.5

Muscular tension tendency: (score 4.5 vs. 1) : OR = 2.3
1.3-4.9

Stress/worry tendency: OR = 1.9
1.1-3.5

Inverse relationship between duration of industrial work and MSDs, largest OR in those employed < 10 years.

Assembly group had high OR (6.7) with regard to neck/shoulder MSD compared to referents.

Significant association between time spent in neck flexion positions < 60°.

Only exposure readings from right arm were used.

(Continued)

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Punnett 1991	Cross-sectional	254 of 275 (92%) meatcutters and wrappers who attended health and safety training classes.	Outcome: Based on self-reported symptom survey. Cases were defined if they met the following: ≥ 20 episodes in the previous year or usual duration of \geq one wk; reported date of pain onset after employment in the retail meat industry; no history of systemic disease related to soft tissue pain; and, no history of acute injury.	Overall Prevalence Neck/Shoulder: 53%	— Male: 1.8 Female: 0.9	1.0-3.2 0.5-1.9	Participation rate: 92%. Stratified by gender and age.	Neck/shoulder disorders associated with external duration of static postures (> 5 sec.) or lifting ≥ 5 lbs. while abducting, flexing or extending the shoulder. Neck/shoulder pain did not vary by job category.
		Workers fulfilling outcome case definition (cases) were compared to non-cases; also compared to the U.S. industrial population.	Exposure: Based on interview and authors' observations.	98% of respondents performed lifting tasks at work. They judged lifting an average load/day was 41 (± 23) lb lifted 33 times and carried 9 feet. Heaviest load = 71 (± 31) lb, lifted 11 times and carried 9 feet/lift. Listing an average load with a 40 to 50% standard deviation can be misleading.	Cutters cut an average 121 (± 278) large pieces of meat/day filled 701 (± 830 boats).	Neck/shoulder cases lifted both the "typical" and "heaviest" loads with greater frequency than non-cases.	Association was found for extended duration of and lifting weight in abduction/flexion and extension of the shoulder.	
			Wrappers filled	374 (± 602 boats/day), Wrapped 1,299 ($\pm 1,365$ boats) and weighed 1,399 boats).				

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Rossignol et al. 1987	Cross-sectional	191 Computer and data processing services, public utilities of Massachusetts State Department, at 38 work sites selected at random from Massachusetts employers of > 50 workers.	Outcome: Self-administered questionnaire case defined as: Neck pain, stiffness, or soreness occurring almost always or missed work due to neck pain, stiffness or soreness. Exposure: Self-reports of number of hr worked each day with a keyboard machine with a VDT. Subjects selected after observation of worksite. 28 of the 191 did not use a computer.	½ to 3 hr of VDT use/day (n = 31); 39% 4 to 6 hr of VDT use/day (n = 28); 57%	No VDT use (n = 28); 25% Up to 3 hr of VDT use compared to 0 hr of use: OR = 1.8	0.5-6.8	Participation rate: In 6 industry groups 67 to 100%. Participation rate: For individual clerical workers; 94 to 99%.	Assessed magnitude of confounding by age, cigarette smoking, industry, educational VDT training.

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ryan and Bampton 1988	Cross-sectional	143 data process operators; using a 0 to 10 point scale, the group with symptom scores of 8 or above ($n = 41$) were designated "cases," and were compared to group with symptom scores of 2 or less ($n = 28$).	Outcome: Based on symptoms occurring three or more times/wk with no physical exam signs, or \geq weekly symptoms with physical exam signs of muscle tenderness or hardening present. Cases were selected by having a combination of symptoms in the lower arm and shoulder/neck area meeting a summary score of eight or more. These cases were compared to a comparison group with a score of 2 or less.	Shoulder: 44% symptom only Neck: 43% symptoms only Neck/shoulder symptoms occurring \geq 3 times weekly with no signs or weekly with signs: 44%	Comparison group had symptom scores < 2 .	More non-cases trained in adjustment of chairs	$p < 0.05$	Participation rate: 99%. Interviewers blinded to questionnaire responses.

Table 2-8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Tola et al. 1988	Cross-sectional	828 Machine operators; 658 carpenters; compared to 657 office workers; All male, ages 25 to 49 years.	<p>Outcome: Postal questionnaire on neck or shoulder symptoms frequency in last year, and influence on work methods, daily duties and activities or leisure time hobbies. Pain Drawing Diagram used to distinguish body areas. For logistic regression model 12 month prevalence of neck and shoulder symptoms on 8 days or more.</p> <p>Exposure: Exposure based on occupation: Machine operators known to be exposed to static loading due to prolonged sitting and low-frequency whole body vibration, fast work pace, and upper trunk twisting.</p> <p>Carpenters exposed to dynamic physical work with varying postures and loads, static loading of neck/shoulder/arm, and male office workers, of whom only 40% were performing routine office tasks.</p>	<p>Daily symptoms: Daily machine operators: 11% carpenters: 8%</p> <p>Change work methods</p> <p>machine operators: 19%</p> <p>carpenters: 21%</p>	<p>Daily symptoms: Office workers: 2%</p> <p>Change work methods</p> <p>Machine vs. carpenter: OR = 1.3</p> <p>Use of twisted or bent postures during work</p>	<p>Machine vs. office: OR = 1.7</p> <p>Carpenter vs. office: OR = 1.4</p> <p>Machine vs. carpenter: OR = 1.3</p>	<p>1.5-2.0</p> <p>1.1-1.6</p> <p>1.1-1.4</p>	<p>Participation rate: 74% machine operators, 67% carpenters, 67% office workers.</p> <p>Adjusted for years in occupation, age, interaction terms tested for, none found.</p> <p>Education, general health, and leisure time activities, car driving included in analysis.</p> <p>Study restricted to males aged 25 to 49 years.</p> <p>Education status ("> some vocational school" compared to "no > some courses") statistically significant for machine operators' and carpenters' reporting of symptoms.</p>

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Vihma 1982	Cross-sectional	40 Sewing machine operators with short work cycles compared to 20 seamstresses.	Outcome: Neck or shoulder complaints defined by questionnaire: Recurrent pain or aching in present work (during or after work). Exposure: Observation and interview; hr continuously sitting, standing time, survey of work postures, length of work cycle. Sewing machine operator cycle time was 30 to 60 sec. in duration. Seamstresses had longer cycle.	Sewing machine operators with neck/shoulder complaints: 98% Seamstresses with neck/shoulder complaints: 60%	PRR = 1.6	1.1-2.3		Participation rate: Not reported. Random selection of participants. Cases and referent group matched for age and duration of employment. Sewing machine operators found to have significantly greater static work compared to seamstresses.

Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Viikari-Juntura 1991	Cohort	154 subjects (72 female, 82 male) from Helsinki, Finland. Subjects were part of a longitudinal study population that started in Finland in 1955; and from 1961 to 1963. During that time, 1084 subjects underwent cross-sectional examination. In 1985, a questionnaire was sent to all subjects; 801 (74%) responded. Of the respondents, 180 lived in the Helsinki area. It was from this group that 162 responded. Eight were excluded due to illnesses. The proportions of the highest income levels in the sample exceeded the Finnish population.	Outcome: Based on Questionnaire data: Ache, pain, stiffness, numbness in their neck/shoulder in last 12 months. Visual analogue scale of intensity disability. Severe neck disability: Pain for >7 days in last 12 months and mean disability index ≥ 15 . Physical exam (P.E.): Two tests for cervical nerve root involvement, neck compression test, shoulder abduction test. Because of small number of abnormal physical findings, the P.E. was eliminated from analysis	10% of female and 2% of male reported severe radicular neck pain	—	Female: Severe neck/shoulder symptoms vs. no symptoms. Alexithymia (low verbal productivity) (continuous): OR = 1.02	0.97-1.1	Participation rate: 90%. Controlled for physical and creative hobbies, no interactions seen. Because of low numbers, males were not included in analysis. Subjects comprised of mostly high socioeconomic status who reported light physical workloads.